

death.

— The Nevada Lore Series focuses on the legends of Nevada and the surrounding areas that help build our culture, from ancient Washoe stories, to Old West ghostly visions, to modern day urban legends.

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[Nevada Lore Series: The murder of Julia Bulette, Virginia City's beloved Madam and Firefighter](#)

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2 Comments

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**Sue Gembrini-Spataro**

Great story. I lived in CaronCity for 12 years...loved it. 4 Streets are named for these 4 founding father-of the town. I now know how/why those street where'd Named.

Like · Reply · 2y



**Robert Pilcher**

Did Abe Curry bring a Son Charles in 1854, that had a Son Charles born in 1860 in Carson City?

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Facebook Comments Plugin

[Carson City](#) [000](#) [Abe Curry](#) [Abraham Lincoln](#) [Arts and Entertainment](#) [Assembly](#) [bowling](#) [Buildings](#) [Buildings.](#) [Business](#) [California](#) [campaign](#) [Capitol](#) [car](#) [carson](#) [cemetery](#) [City](#) [closed](#) [country](#) [county](#) [culture](#) [day](#) [Death](#) [died](#) [dog](#) [eagle](#) [extortion](#) [Family](#) [February](#) [Funeral](#) [Genoa](#) [gold](#) [Gold Hill](#) [Governor](#) [great basin](#) [hauntings](#) [help](#) [Job](#) [JUDGES](#) [Julia Bulette](#) [Kit Carson](#) [Lake](#) [live](#) [Lone Mountain](#) [lost](#) [men](#) [mining](#) [mint](#) [mountain](#) [Moved](#) [Nevada](#) [Nevada State Prison](#) [new](#) [October](#) [Opportunity](#) [Pony](#) [Express](#) [POST](#) [President](#) [Prison Hill](#) [railroad](#) [Recognition](#) [Red](#) [retirement](#) [Rural](#) [Safe](#) [sale](#) [Senate](#) [silver](#) [state](#) [Stroke](#) [tahoe](#) [the Comstock](#) [Truckee](#) [U](#) [Utah](#) [Virginia City](#) [war](#) [Washoe](#) [Comstock](#) [Dayton](#) [Gold Hill Hotel](#) [history](#) [Lake Tahoe](#) [Las Vegas](#) [Legislature](#) [reno](#)

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Ready to make your next career move?  
**Come work with Vacasa!**

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[CLICK HERE](#) for full list of job openings in the Truckee/Tahoe area



### Carson Now daily email newsletter

Click here to get the latest news sent to your inbox every day



1 hour 58 min ago

308 North Carson St. - (775) 883-1717



### LA Bakery

Today's Specials Greek Chicken Special Grilled All Natural Hormone Free Chicken, Tomato, Onion, Feta Cheese, Tzatziki Sauce On Pita Wrap Comes With ...



3 hours 20 min ago

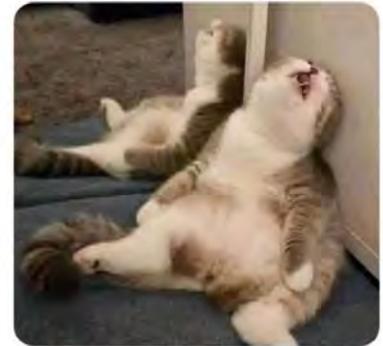
1280 North Curry Street - (775) 885-2253



### Lone Mountain Veterinary Hospital

Happy Friday. Have a great day.

When you need to clean but have no motivation so you just sit there for a while like



3 hours 51 min ago

780 College Pkwy - (775) 883-3136



### Carson City Downtown Business Association



9 hours 14 min ago

## Top Stories

... or see all stories

### Nevada Day Treasure Hunt 2021: Clue 4

Community - Friday, October 8, 2021 - 9:26am



by Kelsey Penrose

Good morning seekers! We are nearly done with our first week of clues, and I've got some theories! Have you made any guesses yet?

Here are the clues we have received so far:

### Break out your sweaters, Carson City: this weekend will be chilly

Community - Friday, October 8, 2021 - 9:13am



by Kelsey Penrose

Good morning Carson City, if you look out your windows this morning, you may find a grey sky warning of a chilly day. We are finally getting some true fall weather, which should be sticking around for a few days, with the potential for hard freezes growing into early next week.

### Carson City Juvenile Services' introduces newest employee Tofi, the Labrador Retriever

Community - Friday, October 8, 2021 - 8:05am



*Carson City Juvenile Services*

Carson City Juvenile Services' newest employee Tofi, a Labrador Retriever, was brought to the Board of Supervisors today to be introduced to the BOS and community of Carson City.

She is a Hungarian Labrador Retriever, who initially began her career as a K-9 Deputy with the Carson City Sheriff's Office. It was decided Tofi was not fit to be a K-9 dog to sniff drugs due to her mellow disposition.

Tofi was rehomed to the Chief of Juvenile Services, Ali Banister, who has now introduced Tofi to the Carson City Juvenile Detention Center.

### State reports drug overdose deaths increased by 55 percent in Nevada from 2019 to 2020

Health & Wellness - Thursday, October 7, 2021 - 6:19pm



*Nevada Dept. Health and Human Services*

The Nevada Overdose Data to Action program, which oversees the surveillance of opioid overdose in the state, announced Thursday that accidental drug overdose deaths among Nevadans increased 55 percent from 2019 to 2020.

### Carson City, Quad County COVID-19 weekly update: 9 deaths, 289 new cases and 186 recoveries

Health & Wellness - Thursday, October 7, 2021 - 5:03pm

*Carson City Health and Human Services*



### Living the Good Life Nightclub-Bistro-Lounge



Photos from Living the Good Life Nightclub-Bistro-Lounge's post



15 hours 14 min ago

1480 N Carson Street - (775) 841-4663



### Michael Hohl Chevy Buick GMC Cadillac

\*\*Sign On Bonus\*\*\*\*Relocation Assistance Available For The Right Candidate\*\*\*\* GM Experience Preferred \*\*BenefitsMedical, Dental & Vision ...



18 hours 2 min ago

3700 N Carson St - (775) 884-4414



### Kadee Mason - American Family Insurance Agent

What does a reasonable amount of time for landlords to make repairs mean in your lease agreements? The answer varies based on the gravity of the ...



Landlord Response Time

[www.amfam.com](http://www.amfam.com)

Illusive as it may be, understanding what a reasonable amount of time is when it comes to handling tenant repairs and requests can make a big ...



18 hours 23 min ago

808 College Pkwy, Ste 106 - (775) 883-5935



Carson City Health and Human Services is providing the Quad County community with a weekly update for the week starting Sept. 30 and ending Oct. 6, 2021.

### 29th annual Carson City Ghost Walk tour of historical, haunted westside happens Oct. 23

Community - Thursday, October 7, 2021 - 2:23pm



Carson City's spooky and intriguing history is explored and theatrically re-lived at the 29th annual all-day Carson City Ghost Walk happening Saturday, Oct. 23.

The Carson City Ghost Walk is a delightfully entertaining and enjoyable way to experience Carson City's Victorian Era and diverse history. Hear about lingering spirits of the past centuries, haunted and paranormal stories and meet characters and supernatural legends as you tour the historic district.

### NDOT prepares for winter snow removal, offers driving tips for motorists

News - Thursday, October 7, 2021 - 2:16pm



NDOT news release

With winter weather forecast in northern Nevada, the Nevada Department of Transportation is prepared to help keep winter roads clear.

### 10 percent of recent Quad County COVID-19 cases have been in fully vaccinated individuals

News - Thursday, October 7, 2021 - 12:23pm



by Kelsey Penrose

Since the end of September, 10 percent of COVID-19 cases in the Quad Counties have been breakthrough cases, according to Carson City Health and Human Services.

A breakthrough case occurs when an individual is fully vaccinated, but still contracts COVID-19.

### Carson City Supervisors approve new townhouse subdivision map, amendment for youth center

News - Thursday, October 7, 2021 - 4:06pm



by Kelsey Penrose

The Carson City Board of Supervisors voted to approve a townhome subdivision map that will create 34 single family residences. Supervisors also approved an interlocal amendment stating that a youth center must be compliant with the Rape Prevention Act.

### Carson City arrests: Man booked for warrant alleging sexual assault against a child

News - Thursday, October 7, 2021 - 10:43am

A 59-year-old man was arrested Wednesday for a felony warrant alleging sexual assault against a child, according to a Carson City Sheriff's Office booking report.



### Carson City Toyota

This month, get great financing on the new 2021 Toyota Highlander AND Highlander Hybrid! See our full line up here: ...



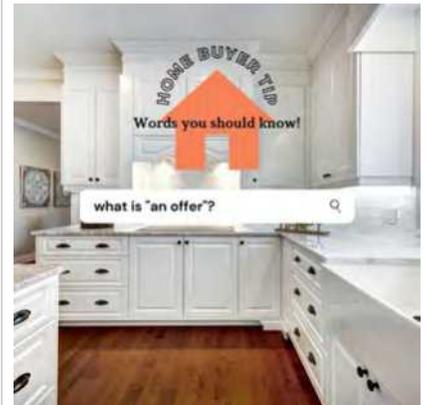
19 hours 23 min ago

2590 S Carson St - (775) 882-8211



### Krisha Caraway - Valley Realty

OFFER: An agreement between a buyer and a seller to purchase real estate



Timeline Photos



19 hours 50 min ago

(775) 400-6650 - NRED S0172941



### Friends of the Carson City Library

Get your scare on in room 4! Our volunteers hand-picked some of the spookiest books and movies for your #Halloween festivities. Come check them ...





### Nevada Day Treasure Hunt 2021: Clue 3

Community - Thursday, October 7, 2021 - 9:34am



by Kelsey Penrose

Good morning seekers! Do you have any ideas so far about where the medallion may be hidden? Let's find out what the newest clue is!

### Dinner and a show: School production of 'Million Dollar Meatballs' coming to Carson City

Arts and Entertainment - Thursday, October 7, 2021 - 9:59am



Try our million dollar meatballs dinner and show. The play "Million Dollar Meatballs" featuring drama students from Bethlehem Lutheran School and Sierra Lutheran High School and directed by Mr. Zachary Karges will be featured for one night only, Oct. 22, 2021 at Luther Hall in Carson City..

### Carson City public safety agencies to hold 'active shooter response' drill at courthouse

News - Thursday, October 7, 2021 - 8:15am



Carson City news release

On Saturday, Oct. 9, 2021, the Carson City Fire Department, Carson City Sheriff's Office, Department of Alternative Sentencing, and Juvenile Services is conducting an "Active Shooter Response" training at the Carson City Courthouse on Musser Street. The one-day training event will focus on response to an active shooter incident using a unified approach.

### Wild Horse Children's Theater to hold auditions for Junior Theater Festival West 2022

Arts and Entertainment - Wednesday, October 6, 2021 - 1:24pm



Wild Horse Children's Theater

We are auditioning to add new cast members for Wild Horse Children's Theater elite Junior Theater Festival Performance Troupe. We are looking for talented young people, ages 10-18, to perform at the Junior Theater Festival West 2022 in Sacramento, Calif.



#### Timeline Photos



21 hours 26 min ago

711 E. Washington St. - (775) 884-4043



#### Colette M. Burau - ReMax Realty Affiliates



#### Timeline Photos



23 hours 20 min ago

716 N Carson St - (775) 250-8031



#### Carson Home Furnishings

If you're looking for something unique, you've come to the right place. #furniture #HomeDecor #InteriorDesign #HomeFurnishings ...



#### Timeline Photos



1 day 56 min ago

1345 S. Carson Street - (775) 885-7712



#### Action Garage Door Company

Perfect weather to use your retractable screen doors! Call us today for your free estimate. 775-246-3667#clearview #retractablescreens # ...



## Comstock Cowboys Concert in Minden postponed due to weather concerns

Arts and Entertainment - Thursday, October 7, 2021 - 9:26am

By Sharon Schlegel

The Friday, Oct. 8 concert with Comstock Cowboys has been postponed due to rain & cold weather forecast for Friday. It will be rescheduled for Late May/Early June 2022. Please hold your tickets for the rescheduled concert in late May/Early June 2022. We will post updated details on the new concert date when they become available.

## Carson City area weather: Caltrans to close 3 Sierra passes Thursday due to coming storm

News - Wednesday, October 6, 2021 - 4:10pm



UPDATE: Caltrans announced it will close three routes over Sierra mountain passes on Thursday due to a storm system moving into the region bringing snow to the upper elevations.

State Route 108 at Sonora Pass will close at noon, State Route 89 Monitor Pass will close at 2 p.m. and State Route 120 will closed at 5 p.m., according to Caltrans.

## New art classes offered Fridays at Carson City's Brewery Arts Center

Arts and Entertainment - Wednesday, October 6, 2021 - 1:50pm

Brewery Arts Center

The Brewery Arts Center is adding two new art classes on Friday's beginning this Friday, Oct. 8 through a new partnership with arts instructor Debbie Corona of the Carson Valley Mobile Art Center.



## Ideas on Tap: Town hall with Carson City Mayor Bagwell set for Oct. 20 at Adams Hub

Community - Wednesday, October 6, 2021 - 1:09pm

Michael Smith, Ideas on Tap

A town hall meeting with Carson City Mayor Lori Bagwell will be the topic for the Wednesday, Oct. 20 Ideas on Tap. We'll start at 6 pm, at the Adams Hub for Innovation, 111 West Proctor Street.



## Halloween Fairytale Express train returns to Mills Park Nevada Day weekend

Arts and Entertainment - Wednesday, October 6, 2021 - 12:48pm

Wild Horse Productions

All aboard the Halloween Fairytale Express. The Carson City Railroad Association, in partnership with Wild Horse Productions, are bringing back the Halloween train ride at Mills Park in Carson City for Nevada Day weekend.



## Photos from Action Garage Door Company Inc's post



1 day 15 hours ago

10116 Hwy 50 East - (775) 246-3667



## Capital Ford

The fact is, all brakes wear out. Having your brakes serviced regularly can help ensure proper and safe braking. Watch this video to learn more ...



## Timeline Photos



1 day 15 hours ago

3660 S. Carson St. - (775) 882-5353



## Battle Born Harley-Davidson

ATTN: The ride up to Virginia City and the Rodeo Friday is cancelled due to weather. Dont worry tho the bar will still be open! See you all out ...



1 day 18 hours ago

2900 Research Way - (775) 882-7433



## The Firm Cryo Spa

Book our deeply exfoliating and hydrating fall facial now! Includes: Yam & Pumpkin Enzyme Peel Soothing Chamomile Tonique Bright Skin Masque Snow ...

## Carson City Supervisors to discuss new townhomes, youth center compliance with assault act, and more

News - Wednesday, October 6, 2021 - 10:47am



by Kelsey Penrose

The next Carson City Board of Supervisor's meeting will take place Thursday, Oct. 7 beginning at 8:30 a.m. in the Robert 'Bob' Crowell Board Room in the Carson City Community Center, located at 851 E. William Street.

Items up for discussion include new townhomes, youth center compliance, a CDC grant and more.

## Pursuit from Reno to Lyon County ends with arrest, driver goes wrong way, nearly hits road crew

News - Wednesday, October 6, 2021 - 10:20am



A 35-year-old man was arrested Tuesday morning following a vehicle pursuit that began in Reno and ended in Fernley, in which the suspect went the wrong way along multiple roadways and nearly struck a Nevada Department of Transportation road crew.

## Nevada Day Treasure Hunt 2021: Clue 2

Community - Wednesday, October 6, 2021 - 9:26am



by Kelsey Penrose

Good morning seekers! While we're still early in the hunt, my brain is already whirling trying to figure out where to find that medallion!

Here are the clues we have received so far:

## Spike in bear activity around Carson City region due to drought and fires, says NDOW

News - Wednesday, October 6, 2021 - 10:59am



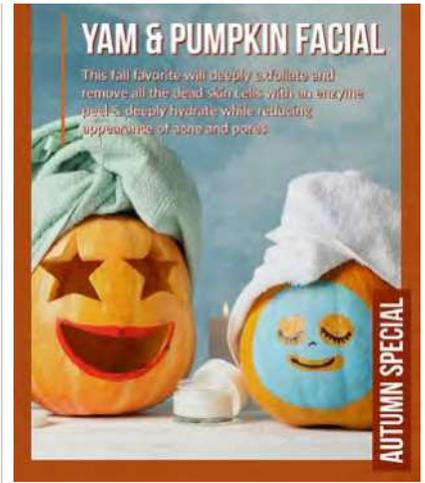
Hungry bears looking to fatten up before winter have been roaming Carson City and surrounding valleys in larger numbers this season and that's in part due to drought and nearby wildfires, according to the Nevada Department of Wildlife.

## NHP, Nevada law enforcement steps up patrol efforts as part of pedestrian safety campaign

News - Tuesday, October 5, 2021 - 4:13pm

Trooper Charles Caster, NHP

The Nevada Highway Patrol has partnered with other participating Nevada law enforcement agencies in the Joining Forces program and is urging pedestrians and drivers to be aware of each other and to share the road responsibly.



2 days 1 hour ago

602 N Curry Street - (775) 315-9080



## Grocery Outlet Carson City

Right now, we've got great deals on products you love at 1831 North Carson Street in Carson City. Between now and October 12th, you can get ...



2 days 3 hours ago

1831 North Carson Street - (775) 882-6199



## Michael Hohl Subaru

Check it out: <https://www.torque news. ...>



## Is Subaru Moving To An All EV Lineup? Its New EV Division Isn't The Whole Story | Torque News

[www.torque news.com](http://www.torque news.com)

Is Subaru moving to an all EV lineup like other automakers with its newly-announced all-electric vehicle division? Here's what customers can ...



2 days 16 hours ago

2910 S. Carson Street - (775) 885-0400



## Bella Vita Bistro



## Girlfriends Golf Tournament at Dayton Valley raises money for area girls' high school golf teams

Sports - Tuesday, October 5, 2021 - 3:48pm

By Denise Clodjeaux

Several local girls golf teams will get a financial boost this week. The annual Girlfriends Golf Tournament, held Sunday, Oct. 3 at Dayton Valley Golf Course, netted \$3,795 which will be donated to several girls' high school teams.



### Girlfriends Golf

## Navy brings mobile virtual reality experience to Carson High School

News - Tuesday, October 5, 2021 - 2:30pm



U.S. Navy news release

Navy recruiting leadership visited Carson High School on Tuesday in search of high-ability students who have what it takes to excel in high-demand fields, such as nuclear engineering, cryptology, and information technology.

## Inaugural 'Plein Air' watercolor competition offers \$2,500 in cash prizes, followed by public reception at Governor's Mansion

Community - Tuesday, October 5, 2021 - 12:57pm



"Rabbit Brush Rain" Watercolor by Colleen Reynolds

by Kelsey Penrose

Watch watercolor artists paint "En Plein Air" in the historic district on Oct. 14, 15 and 16 as part of inaugural competition, which is offering \$2,500 in cash prizes.

On Sunday, Oct. 17 there will be a reception at the Governor's Mansion, located at 606 Mountain St. from 1 p.m. to 5 p.m., which will include an Art Scavenger Hunt, People's Choice Award, a raffle, music, appetizers, a painting awards presentation and an action.

## Carson City emergency crews respond to crash at College Parkway and Roop

News - Tuesday, October 5, 2021 - 1:16pm

Carson City Fire Department and sheriff's deputies responded Tuesday afternoon to a crash near the intersection of College Parkway and Roop.

## Peace poster contest entries on display at Nevada Artists' Association Gallery in Carson City

Community - Tuesday, October 5, 2021 - 12:36pm

Carson City Host Lions Club

Local entries for the Lions International Peace Poster Contest are now on display at the Nevada Artists' Association Gallery, 449 King Street, Carson City. The Gallery is open Tuesday through Sunday, 12 p.m. to 4 p.m. The Peace Poster entries will be on display at the Gallery until Oct. 22.

Happy Fall Today's Lunch Special is a Tri Tip Cheddar Melt that is great with our Carrot Ginger Soup ...



2 days 21 hours ago

1304 South Stewart St. - (775) 515-4300



### Concept EBikes



2 days 23 hours ago

3633 Research Way - (775) 882-0555



### Mountain Lakes Estates

Chef Carlos is of the grill!



Photos from Mountain Lakes Estates's post



2 days 23 hours ago

1701 S Sutro Terrace - (775) 432-3808



### Nevada Dav



### Carson City schoolchildren to celebrate Walk to School Day this Wednesday

News - Tuesday, October 5, 2021 - 10:53am



#### Carson City School District

Students in Carson City are invited to participate in various Walk to School Day events Wednesday, Oct. 6, 2021. Many parents, teachers and administrators plan to join students in organized walks to promote safely walking or bicycling to school.

### Carson City arrests: Woman attempts to pick up property from jail under influence of meth

News - Tuesday, October 5, 2021 - 10:51am



Three were arrested Saturday following an investigation after one of them attempted to pick up property at the Carson City jail while allegedly under the influence of drugs, according to a Carson City Sheriff's Office booking report.

### Nevada Day Treasure Hunt begins today with first clue

Community - Tuesday, October 5, 2021 - 9:27am



#### by Kelsey Penrose

Good morning Carson City! Are you ready to begin the annual Nevada Day Treasure Hunt?

This may be the last year for some time to hunt, as the current organizers have announced they will not be taking it on next year. The current organizers, including Jennifer Mahe who spoke on the Treasure Hunt's history back in 2019, stated that they took over for the Olson Family, who began the hunt back in 2000.

### Forest Service uses sheep to reduce fire fuels near Jacks Valley south of Carson City

News - Tuesday, October 5, 2021 - 8:42am

#### U.S. Forest Service

As part of the Carson Ranger District's Hazardous Fuels Reduction Program, the Humboldt-Toiyabe National Forest recently released sheep in the Jacks Valley Wildlife Management Fuels Reduction Project area just south of Jacks Valley Road in Carson City, Nev.

From approximately mid-October through November, the sheep will consume cheatgrass and other non-native vegetation over a 2,000-acre project area on National Forest System lands.



The parade is almost full. If we dont have an entry, we cant give you a spot.



3 days 12 hours ago

716 N. Carson St. - (775) 882-2600



### Carson Mall

What a great night !!!! Thank you every one!!!! Tag us with all your pictures!!



#### Photos from Carson Mall's post



5 days 10 hours ago

1313 South Carson Street - (775) 671-8150



### Action Home Furnishings

HEY HEY Happy Saturday ACTION Friends and Followers! FRESH OFF THE TRUCK ALERT!!! We had a truck roll in LATE in the day yesterday! Complete with TV ...



#### Photos from Action Home Furnishings's post



5 days 22 hours ago

2040 East William Street - (775) 884-3030



### Capitol City Loans

Looking for a Travel Trailer? Come and check out ours 2005 Nash M-30U in excellent condition! Call us for more information at 775-882-8882





## Adams Hub for Innovation announces launch of executive speakers series

Business - Tuesday, October 5, 2021 - 7:12am



### Adams Hub for Innovation

CARSON CITY — Adams Hub Center for Innovation is proud to announce the first of its Adams Hub Executive Speakers Series. Speakers are selected based on their expertise on topics that benefit small business owners and executive professionals in the Carson City region.

## Amodei 'torn' between Nevada governor bid and possibly serving in GOP majority

Nevada Politics - Monday, October 4, 2021 - 5:29pm



### Humberto Sanchez, The Nevada Independent

Rep. Mark Amodei (R-NV) said he is still undecided about possibly running for governor as he considers concerns about the economy and the possibility of serving in a House GOP majority following the midterm election.

"I'll be honest with you, I'm torn," Amodei said in an interview Friday, when asked which way he is leaning.

## Veteran Affairs announces new director at VA Sierra Nevada Health Care System

Announcements - Monday, October 4, 2021 - 4:52pm

### Department of Veterans Affairs

RENO — The Department of Veterans Affairs is pleased to announce the appointment of Kevin Amick as Medical Center Director for VA Sierra Nevada Health Care System in Reno, Nev.

## Vitalant hosts blood drive Tuesday at Western Nevada College

Health & Wellness - Monday, October 4, 2021 - 4:27pm



### Western Nevada College

By participating in the Tuesday, Oct. 5 blood drive presented by Vitalant at Western Nevada College's Carson City campus, donors can help provide a sufficient supply of blood for transfusions locally.

## Nevada health insurance plans and rates approved for the individual health insurance market

Health & Wellness - Monday, October 4, 2021 - 4:22pm

### Photos from Capitol City Loans's post



1 week 1 day ago

5951 US Highway 50 East - (775) 882-8882



## Quail Ridge Animal Hospital

September 28 is World Rabies Day. Make sure your dog is fully vaccinated at your upcoming wellness exam. ...

### Wellness Exams - Quail Ridge Animal Hospital

quailridgepets.com  
Wellness Care Although the advances that modern medicine have afforded us make it easier than ever for Quail Ridge Animal Hospital to treat your ...



1 week 3 days ago

937 Mica Dr, Ste 18 - (775) 267-4888



## PhoneFix Center

We activate Ultra mobile, all plans have unlimited talk to 80+ country include Mexico.

	250MB	2GB	3GB	5GB	10GB	UNLIMITED	UNLIMITED
12	\$10	\$14	\$20	\$25	\$30	\$40	\$50
6	\$11	\$15	\$21	\$27	\$35	\$45	\$55
3	\$13	\$16	\$22	\$28	\$36	\$46	\$56
1	\$15	\$19	\$24	\$29	\$39	\$49	\$59



1 week 6 days ago

1229 S. Carson St. - 775-883-9999



## Sassafras Eclectic Food Joint

Check it out on Saturday Sept 25th!



### Bryan McPherson and Kat Heart live at Sassafras this Saturday

carsonnow.org  
Don't miss the return of international touring artist Bryan McPherson to Sassafras on Saturday, Sept. 25 in Carson City. Bryan brings an intensity ...



1 week 6 days ago

1500 Old Hot Springs Rd - (775) 884-4471



## Michael Hohl Honda

Nice pre owned Honda Ridgeline in Stock! It won't last long stop in and take it for a drive!



### Nevada Division of Insurance

CARSON CITY — In preparation for Open Enrollment next month, the Nevada Division of Insurance has made public the approved health insurance rates for consumers who shop on the individual health insurance market, both on and off the Silver State Health Insurance Exchange (Exchange), which is the state agency that oversees and connects eligible Nevada residents to affordable health and dental plans through [Nevada Health Link](#).

### Mile High Jazz Band presents 'Big Band in the Black Box'

Arts and Entertainment - Monday, October 4, 2021 3:41pm



By David Bugli, Mile High Jazz Band Leader

Following five months of outdoor dinner shows at Living the Good Life, the Mile High Jazz Band is bringing their October performance indoors. They will perform "Big Band in the Black Box" on Tuesday, Oct. 12, 2021, from 7:30 to 9:30 p.m. in the Maizie Harris Jesse Black Box Theater at the Brewery Arts Center, 449 W. King St., Carson City. Patrons may enter through the Artisans Store entrance.

### Fire tornado prediction tools developed by UNR, DRI to be used during extreme wildfires

News - Monday, October 4, 2021 - 2:18pm

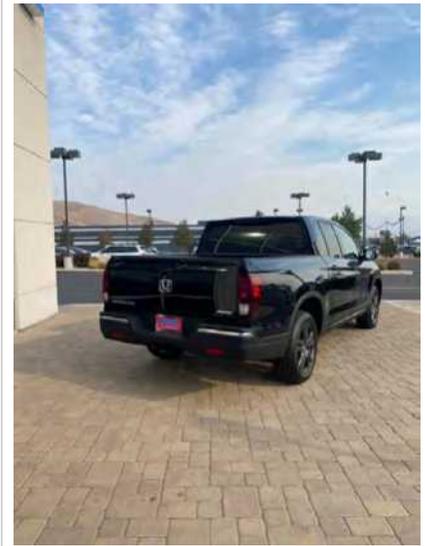


By Kelsey Fitzgerald and Mike Wolterbeek

With massive wildfires plaguing the western United States, scientists have been tracking an increase in dangerous wildfire-generated extremes, including fire-generated thunderstorms and tornados embedded in wildfire plumes that can reach up to a mile high.

- 1 2 3 4 5 6 7 8 9 ... next > last »

work fast long stop in and take it for a drive:



2 weeks 1 day ago

(775) 885-0400



### Northern Nevada Coin & Bullion

"Jewelry Makes The Perfect Gift" Northern Nevada Coin offers this beautiful Newman's sterling silver money clip with an 1890 CC ...



3 weeks 1 day ago

601 North Carson St. - (775) 884-1660



### Carson Lanes Family Fun Center

When it comes to the classics, we're all about making it a double!!! ...



1 month 2 weeks ago

4600 Snyder Ave - (775) 883-2606



### Carson City Library

Want to learn more about Windows 10? Register for our online class and learn at your own pace!



#### Virtual Windows 10 for Beginners

buff.ly For high school students and adults, join us virtually via YouTube. Watch our pre-recorded virtual class: Windows 10 for Beginners. This class is ...



1 month 4 weeks ago



## Casino Fandango

\*\*\*\*\$500 sign Bonus after 90 days of employmentPlease apply here: ...



2 months 6 days ago

3800 S Carson St - (775) 885-7000



## Tahoe Screens - ClearView Retractable Screens

Beautiful @clearviewretractablescreen  
French doors installed @thefirmcryospa\_nv  
today. #spaday #cryo #photobomber  
#downtowncarsoncity # ...



### Photos from Tahoe Screens - ClearView Retractable Screens's post



3 months 3 weeks ago

<http://www.tahoescrreens.com> - (775) 842-6307



## AlohaTech



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## MASON VALLEY

# PlanCom denies applications for meat packing facility

**Keith Trout**

Published 9:00 p.m. PT July 15, 2014 | Updated 9:11 p.m. PT July 15, 2014

Although the applicant talked of some changes and the uniqueness of the situation due to its past use for a similar operation, the Lyon County Planning Commission by 6-0 vote denied the variance requests for a meat packing facility at its July 8 meeting.

Several people spoke in opposition to the requests from Abe's Kosher Meats, LLC/Hillel Shamam, LLC, for a variance of setback requirements for a small-scale slaughterhouse/meat packing/processing facility and for a special use permit for those uses at 150 Nevada 339 in Yerington.

The Planning Commission initially denied the variance, for which it has the final decision unless it is appealed, and cited that action in denying the special use permit.

However, the Lyon County Planning Department said the applicants indicated they planned to appeal the variance decision to the Board of County Commissioners and the SUP automatically goes to that board for final action, which would come in August.

Speaking on behalf of the application were Jim Cavilia, an attorney representing the applicant, Dave Kitchen of Shaw Engineering, which was doing engineering work on the project, and project owner Hillel Shamam.

Speaking against the proposal were Brad Johnston and David Peri of Peri & Sons Farms, and adjacent property owners Mike Florio, Diane Fulstone and Rachelle and Michael Thomas, who spoke of harm to their property values and quality of life if a meat packing facility moved at that site.

Lyon County in 2011 approved new setback requirements for meat packing facilities in response to a meat processing facility that was being considered elsewhere in Mason Valley. The applicants facilities on the property don't come close to meeting those setback standards.

The applicant is requesting these actions to allow it to install a custom Kosher and Hajal livestock slaughterhouse and processing facility at this former meat packing plant site. According to the staff report, the applicant proposes production of 480 head of beef per week, or 120 beef per day, and periodically 150 head of sheep and/or goats for special orders. It is planned to operate year-round, 24-hours per day, four-days per week.

The report, based on the applicant's report, continues to say the animals would be received during evening hours, led directly to pens and then into the final processing building, with no animals remaining in pens overnight. No grazing would be conducted, the report continued, and approximately 10 would be in outside, covered and walled pens, at maximum.

Cavilia said this is a unique issue and opportunity due to the existence of the facility there that has been used for meat processing in the past. He said the plant would be highly regulated, as it is subject to USDA permits and regulations, with a USDA official on site when it is operated. He also said the evaporation and wastewater ponds would be subject to Nevada Division of Environmental Protection regulations and oversight, and they are located above the flood plain.

Kitchen talked about the wastewater treatment and evaporation ponds, which he said are double-lined and have other safeguards to prevent contamination.

Johnston, though, said while NDEP regulates the ponds, Lyon County decides where they may be placed.

He explained Peri & Sons owns agricultural property across the Walker River to the east of the proposed meat packing facility, on land which is certified for organic leafy greens and this meat packing facility operating across the river would cause them to lose that certification, he said. He said it was a lengthy process for this property to be certified.

Peri said he supports economic development in Mason Valley but that he didn't feel this was a proper location for a meat packing facility due to its adverse impacts on neighboring property owners. He said he would offer to have his company level land for corrals if the applicants wished to open in another location.

"I'm not anti-business, but my concern is with (organic certification) of our leafy greens," Peri said.

Johnston said they had met with representatives of the applicants, including Cavilia, but still could not support the planned facility. He said they told of land where a feedlot is located

that would be available for such a facility, but the applicants hadn't contacted the property owner.

Cavilia said they hadn't ignored the request but hadn't been able to inquire about it yet and were pursuing this option first.

The neighboring property owners talked of the loss of their investments due to what they felt would be adverse impacts on the valuation of their property if the meat packing facility opened, plus Rachelle Thomas said her realtor when they bought the property located just south of the property involved in this application told them a meat packing facility would not operate there because rules had changed.

There also were concerns about odors, flies and other negative impacts.

Cavilia said they couldn't promise there would be no odors but he and Kitchen said they would be minimal, based on other such operations and how this would be done, especially at the treatment plant.

Johnston mentioned the presence of manure as negatively affecting the organic certification, but Shamam said the manure would be very minimal due to the short amount of time the animals would be on site before processing. Shamam also said there would be opportunities for employment.

## Examples of Properties Devalued by Factory Farms

### Studies & Reports

In describing the economic costs of CAFOs to rural communities, the recent Union of Concerned Scientists report stated that “because property values are reduced near CAFOs, the residential tax base may suffer as well.”

~ Doug Gurian-Sherman, Union of Concerned Scientists, *CAFOs Uncovered: The Untold Costs of Confined Animal Feeding Operations*, at 61 (April 2008).

The recent Pew Commission report on industrial farm animal production described the various negative impacts that factory farm facilities have on the environment, public health, animal welfare, and rural communities. The report did not directly address declining property values, but did note the negative influence factory farms have on rural social capital and the rights of neighbors to enjoy their own properties.

~ Pew Commission on Industrial Farm Animal Production, *Putting Meat on the Table: Industrial Farm Animal Production in America*, at 40-49 (April 2008).

A 2012 report by Dr. John Kilpatrick of Greenfield Advisors evaluates a Colorado property and the impacts a nearby CAFO has on its value. The report explains that the principles within the report would be applicable to the appraisal of any property near a CAFO.

~ John A. Kilpatrick, *In re: Delta County* (Aug. 22, 2012).

This report was prepared to assist local boards of health who have concerns about CAFOs in their communities and to help them “understand their role in developing ways to mitigate potential problems associated with CAFOs.” The report states that “[t]he most certain fact regarding CAFOs and property values are that the closer a property is to a CAFO, the more likely it will be that the value of the property will drop.” It also noted that “[d]ecreases in property values can . . . cause property tax rates to drop, which can place stress on local government budgets.”

~ Carrie Hribar, National Association of Local Boards of Health, *Understanding Concentrated Animal Feeding Operations and Their Impact on Communities*, at III, 11 (2010).

A technical report for the Pew Commission report discussed various CAFO studies and found that: “Industrialization of animal agriculture leads to the reduced enjoyment of property and the deterioration of the surrounding landscape, which are reflected in declining home values and lowering of property tax assessments. Recurrent strong odors, the degradation of water bodies, and increased populations of flies are among the problems caused by CAFOS that make it intolerable for neighbors and their guests to participate in normal outdoor recreational activities or normal social activities in and around their homes.”

~ Pew Commission on Industrial Farm Animal Production, *Community and Social Impacts of Concentrated Animal Feeding Operations*, at 31.

The National Association of Realtors has put together a “field guide” that explains what CAFOs are and how they can impact property values. The guide lists several studies and notes that, while a few studies have found a positive impact, “most studies have found a negative relationship between feedlots and property values.”

~ National Association of Realtors, *Field Guide to Impacts of Animal Feedlots on Property Values* (Sept. 2013).

In Iowa, one 1996 study found that proximity to a hog CAFO decreased neighboring property values in the following order: 40% within ½ mile; 30% within 1 mile; 20% within 1.5 miles, and; 10% within 2 miles.

~ William J. Weida, *The CAFO: Implications for Rural Economies in the U.S.* 1 (Colo. College & GRACE Factory Farm Project 2004) (citing Padgett & Johnson).

Another Iowa study found that there may be a 1-10% reduction in property values of residences upwind of new CAFO facilities, and that the drop in value “helps explain opposition by rural residents to large-scale feeding operations.”

~ Joseph A. Herriges et al., *Living with Hogs in Iowa: The Impact of Livestock Facilities on Rural Residential Property Values* 19-20 (Iowa State Univ. Ctr. for Agric. Dev. Working Paper 03-WP 342 (Aug. 2003)).

A 1999 study in Missouri found that the average loss of land value within three miles of a CAFO was \$112/acre.

~ Mubarak Hamed et al., *The Impacts of Animal Feeding Operations on Rural Land Values* 2 (Cmty. Policy Analysis Ctr., Univ. of Mo., May 1999) (finding that “there is a relationship between proximity to a CAFO and the value of property”).

Studies cited by Dakota Rural Action found that property within a 3-mile radius of a CAFO loses 6.6% in property valuation, and property within 0.10 mile of a CAFO loses up to 88% in property valuation.

~ Dakota Rural Action, *CAFO Economic Impact* (June 2006) (citing North Central Regional Center for Rural Development (1999:46); Siepel et al. (1998)).

A Sierra Club study reported that county assessors in at least eight states lowered property taxes for neighbors of factory farms.

~ William J. Weida, *Nutrient Management Issues* (GRACE Factory Farm Project, Apr. 4, 2001) (citing Sierra Club, *Property Tax Reductions* (Mar. 13, 2000)).

A study in Berks County, Pennsylvania evaluated the impact of potential local disamenities on neighboring properties. It found that the impacts of CAFOs on neighboring property values did not vary significantly by species or by differences in the sizes of the operations.

~ Richard Ready & Charles Abdalla, *The Impact of Open Space and Potential Local Disamenities on Residential Rural Property Values in Berks County, Pennsylvania* i (Penn. State Univ., Staff Paper No. 363, June 2003).

This study evaluated the influence of proximity to swine facilities on the sale price of residential properties, using a GIS-based hedonic model. The study reported that “[r]esults indicate a negative and significant impact on property value from hog operations.” The study also found that the modeling “may be a promising technique for establishing setback guidelines, for assessing property value damages resulting from animal operations, and for evaluating potential property value impacts to surrounding properties when siting a new CAFO.”

~ Milla et al., *Evaluating the Effect of Proximity to Hog Farms on Residential Property Values: A GIS-Based Hedonic Price Model Approach*, 17 URISA Journal 27, 30–31 (2005).

A Putnam County, Missouri study found a \$58/acre loss of value for properties within 1.5 miles of a CAFO facility.

~ William J. Weida, *The Evidence for Property Devaluation Due to the Proximity to CAFOs* 6 (Col. College & GRACE Factory Farm Project, Jan. 21, 2002).

Three different North Carolina studies, described in a presentation at the University of Kentucky, found that proximity and animal density have significant, negative impacts on the market values of residential properties.

~ Michael Thomas et al., *A Comparison of Three Recent Hedonic Models of Hog Farm Discommodity in Coastal North Carolina: Evidence of Diseconomies of Scale and Brown Zones* (May 2003) (citing studies of Bruton, Ansine etl al., and Kim).

A 2008 University of Northern Iowa study analyzed house sales in Black Hawk County, Iowa to determine the effect of hog CAFOs on property values. It found “large adverse impacts suffered by houses that are very close (within 3 miles) to and directly downwind from a CAFO.”

~ H. Isakson & M. D. Ecker, *An Analysis of the Impact of Swine CAFOs on the Value of Nearby Houses* 19 (Univ. of N. Iowa Technical Report, July 23, 2008).

A 1996 newsletter from EPA’s National Center for Environmental Economics reported on an early North Carolina State University study that used hedonic analysis to make various findings on factory farms and their negative impacts on residential land values.

~ USEPA, National Center for Environmental Economics, *Effects of Hog Operations on Residential Property Values*, 3:12 Newsletter (Dec. 1996).

A recent white paper by the Institute of Science, Technology and Public Policy reported on the negative impacts hog CAFOs have in Iowa, including “marked[] and consistent[]” decreases in land values and quality of life in areas near CAFOs. The report noted a study finding that “[p]roximity to a CAFO can reduce the value of a home by 40%.”

~ Institute of Science, Technology and Public Policy, *Concentrated Animal Feeding Operations (CAFOs): Assessment of Impacts on Health, Local Economies, and the Environment with Suggested Alternatives* 3, 6 (post February 2007) (citing study of Park, Lee, and Seidl).

## Articles

This 2001 article in the *Appraisal Journal* explains how CAFOs can negatively impact proximate property values, and lists several factors that should be considered in valuing those properties.

~ John A. Kilpatrick, *Concentrated Animal Feeding Operations and Proximate Property Values*, 39:3 *Appraisal J.* 301 (2001).

A 2012 press release reported that property owners in Illinois were awarded a 12.5% reduction in their property value based on the effects of a neighboring swine CAFO. The reduction applied retroactively from the time the CAFO was constructed.

~ CRAPC & ICCAW, *Neighbors of Illinois Swine CAFO Claim Victory in Property Tax Appeal* (Sept. 6, 2012).

A 2007 article in the *Agriculture and Human Values* journal evaluated studies on industrialized farming and community impacts from the 1930s forward. It reported predominantly detrimental effects, including a decline in real estate values for residences close to hog CAFOs.

~ Lobao & Stofferahn, *The Community Effects of Industrialized Farming: Social Science Research and Challenges to Corporate Farming Laws*, *Agric. & Human Values* (2007).

In Waseca County, Minnesota, a county assessor designed a “smell location chart” to determine reductions in values of properties near feedlots. Factors in the percentage of reduction allowed included the proximity to the feedlot, the number of animals, and the presence of a manure lagoon.

~ Douglas Clement, *Knee Deep in Feedlot Feuds*, *FedGazette*, July 2001.

In January 2007, Indiana residents turned out to testify before the state legislature on a CAFO moratorium bill. One woman testified that a businessman was “driven to suicidal thoughts because he was unable to sell his home after six years because of the odor from a nearby CAFO.” Another testified that “[d]eferred property value because of CAFOs mean [sic] decreased revenue from property taxes, which means less money for our schools.”

~ Jondi Schmitt, *Hoosiers Voice CAFO Concerns: Proposed Bill Would Put Three-Year Moratorium on Start of Construction*, South Bend Tribune, Jan. 30, 2007.

The Indiana House passed a bill in February 2007 that would prohibit new CAFOs within 1 mile of cities, towns, schools, and health facilities. One representative who supported the bill said he “want[ed] the pork industry to grow” in Indiana, but that growth could happen “while having respect to our neighbors.” “CAFOs do decrease property values,” he said.

~ Niki Kelly, *General Assembly: House Restricts Feed Farms*, The Journal Gazette, Feb. 22, 2007.

A Michigan Land Use article reported that a tax tribunal reduced the assessments for properties adjacent to CAFOs. It ordered local officials to reduce the taxable values of at least five rural homes by 35% based on problems with stench from a hog livestock factory, and on “slim sale chances” for the homes.

~ Patty Cantrell, *Michigan Tax Tribunal Recognizes Hog Factory Stench* (Mich. Land Use Inst., Dec. 7, 1999).

This 2004 paper debunked assumptions underlying CAFO-proponent arguments, including those regarding CAFOs and property use. It noted: “CAFOs generate odor, air and water pollution, all of which have a direct impact on neighboring properties. The closer the neighboring property, the more severe the impact is likely to be. . . . The resulting loss of exclusive use by neighboring properties lowers their values and ultimately also lowers the taxes generated from these properties. Suing the offending party for these nuisance activities could potentially compensate the neighboring property owners. To prevent this, factory farming interests have attempted to sponsor legislation to prohibit nuisance suits for agricultural pollution.”

~ William J. Weida, *Considering the Rationales for Factory Farming* (for presentation) 10 (Mar. 5, 2004).

Clark County, Illinois established assessment abatements for fifty residential homes around a hog CAFO in the following order: 30% reduction within ½ mile; 25% reduction within ¾ mile; 20% reduction within 1 mile; 15% reduction within 1 ¼ miles; 10% reduction with 1 ½ miles.

~ William J. Weida, *The Evidence for Property Devaluation Due to the Proximity to CAFOs* 6 (Col. College & GRACE Factory Farm Project, Jan. 21, 2002).

A 2006 article in the *Journal of Ecological Anthropology* recognized the ill effects of factory farms on neighboring properties: “In addition to their negative effects on the local economy and tax base, large corporate operations are the source of environmental issues that threaten the property values of rural and urban residents. This strains the economic base and places higher burdens of taxation on remaining residents.”

~ Barbara J. Dilly, *Tax Policy and Swine Production in Iowa*, United States, 10 *J. Ecological Anthropology* 45, 48 (2006).

A Peoria, Illinois newspaper reported that county officials lowered property values for at least 20 people with homes within two miles of a large sow farm and its odor. The tax board decreased assessments by 30% for neighbors with 1 ½ miles of the operation, and 10% for those within 2 miles of the facility.

~ *Board Smells Lower Land Values near Hog Farm*, The Journal Star, May 6, 1998, at A1.

An Iowa paper reported on the results of the University of Northern Iowa study mentioned above. One interviewee said that his neighbor had been offered \$1 million for his land before plans for a hog lot were announced, but that after the announcement, “the would-be buyer walked away.” “He lost almost \$1 million right there . . . . And it’s not necessarily smell. It’s psychological . . . . They don’t want anything to do with them (hog lots) if they see them.” Another interviewee, who had recently bought land in the area, said she “would not have bought the house and all the surrounding property . . . at above market value . . . if a CAFO was going to be built a mile away. . . . And to tell you the truth, I’ll sell my property at a huge loss to move away if they build these things.”

~ *UNI Study: Hog Lot Cuts up to 15% off Nearby Home Values*, Waterloo Courier, Mar. 12, 2007.

A 2006 Letter to the Editor in opposition to proposed legislation that would weaken Michigan’s environmental laws described the “severe pollution” that CAFOs cause. The author explained that the growing number of CAFOs in Michigan was “threatening our public health, our rural communities and the viability of Michigan’s 52,000 farms.” She also noted that “[t]he stench from CAFOs has led to reductions in property values of up to 70 percent by the Michigan Tax Tribunal for nearby residents no longer able to enjoy or sell their homes.”

~ Anne Woiwode Letter to the Editor, *Animal Sewage from Livestock Farms Threatens Communities*, Kalamazoo Gazette, May 15, 2006.

In February 1998, residents of Caribou, Maine petitioned the city council for a temporary ban on factory pig farms. Among concerns were “strong odor from waste, surface and ground water contamination and plummeting property values.”

~ Gloria Flannery, *Caribou Councilors Seek Ban on Piggery; Fears of Pollution, Odor Lead to Ordinance Proposal*, Bangor Daily News, Feb. 25, 1998.

In an article summarizing newspaper coverage of concerns about large-scale swine facilities (LSSF) in Illinois, a “distinct undercurrent” of claims against the facilities was that they were “difficult for communities.” Specifically, “[s]ources were concerned that LSSF were socially disruptive: they went against traditional community values, destroyed the community’s history, violated ethics of neighborliness, and created community conflict. In addition, they were concerned that the community would have to develop infrastructure capacity to handle the effects of LSSF, paying for social services, schools, and health care for migrant workers and cleaning up spills and abandoned lagoons. Those opposed to LSSF also maintained that the large-scale operations had no overall economic benefit for communities because they displaced more jobs than they created, decreased property values and made alternative industries, such as tourism, less viable.”

~ A.E. Reisner, *Newspaper Coverage of Controversies about Large-Scale Swine Facilities in Rural Communities in Illinois*, 83:11 J. Animal Sci. (Nov. 1, 2005).

Coverage of the 2007 Food and Family Farm Presidential Summit in Iowa noted that “many neighbors say the [CAFOs] stink up the air and foul the water, devastate their property values, and drive small farmers out of business.”

~ Jennifer Jacobs, *Candidates Tout Their Farm Credentials*, Des Moines Register, Nov. 11, 2007.

### Cases

In a 2013 decision by the Idaho Board of Tax Appeals, a property owner was awarded a 20% reduction in his residential property assessment due to his property’s proximity to a CAFO. As evidence, the

property owner explained that his property was and would be negatively impacted by the CAFO because of dust and odors, impaired views, nearby (or migrating) contamination and disease, loud noises, etc. He also presented an appraiser working paper that summarized CAFO impacts on nearby property values, a summary of a study done in a neighboring county that quantified property value decreases based on proximity to CAFOs, and a real estate broker's letter that estimated a decrease in his property's value of 20-30%. The Board found that the County should have made appraisal adjustments based on these factors, and ordered a 20% reduction relying primarily on the neighboring county study, the appraisal paper, and the real estate broker's statement.

~ *In the Matter of the Appeals of Joe Morton*, Nos. 12-A-1377 & 12-A-1379 (Idaho Bd. of Tax Appeals, April 22, 2013).

In a 1997 Indiana Tax Court case, property owners asserted that a state board did not adequately consider the negative effects a proximate hog operation had on their neighborhood when assessing their property. To support their claim that odors from the operation impaired the enjoyment of their property, the plaintiffs presented two jars of air taken from their yard to the hearing officer. The Tax Court held that the plaintiffs met their burden of proving their assessment was incorrect based on the proximate hog operation's effect on the desirability of their neighborhood. Relevant evidence that the plaintiffs presented included the two jars of air "redolent with swine" (though unopened, the hearing officer conceded they would smell bad), and verbal testimony about how the odor impaired the enjoyment of their property (they were unable to play tennis, open windows, or hang clothes out).

~ *Corey v. State Bd. of Tax Comm'rs*, 674 N.E.2d 1062, 1063, 1065-66 (Ind. Tax. Ct. 1997) (reversing state board's assessment on these grounds).

In a case before Indiana's Court of Appeals that was basically a zoning challenge to a proposed CAFO, some people who lived near the proposed CAFO presented evidence that their property values would decline if the CAFO were built. They presented testimony by their Township Assessor, who said:

The first thing that has to happen if this hog operation goes in, is the neighborhood value will have to be lowered from a good to a fair or a poor . . . . [T]here's some houses like Flynns [sic], Bowmans and Jerry Marsh's, David Helt's there's some of them that the Sexton's house, there's two of them there that are pretty new houses, Steve Bowman's sister just built a new house up there. I wouldn't be surprised if they wouldn't drop 30 percent, I don't think it would be out of the question. So the property values will decrease in this area.

The Court held that the testimony was enough to show that the people near the proposed CAFO would "suffer a pecuniary loss" if the CAFO permit were granted.

~ *Sexton v. Jackson County Bd. of Zoning Appeals*, 884 N.E.2d 889, 893-94 (Ind. App. 2008).

In 2002, a Nebraska Court held that a tax commission should have considered the effect of a nearby factory farm on a taxpayer's property value. The taxpayer presented evidence from an appraiser who "considered that a potential buyer would take into account the odor produced by the hog farrowing facility," and adjusted the property's value downward for that and other reasons. The Court made several strong statements illustrating its conviction that factory farms impact neighboring property values:

In the context of negotiations between a willing buyer and seller to arrive at fair market value, the neighboring hog facility and the house's location would unquestionably affect the market value of Livingston's house. Any other conclusion would mean that two identical houses, one

located next to the railroad switching yard and the other next to the country club golf course, have identical values – an obviously arbitrary and illogical conclusion that no reasonable person would reach. . . .

That many potential buyers would not look favorably upon the hog facility, and judge the home's value with reference thereto, is demonstrated by some well-known Nebraska cases in which homeowners have successfully sued hog facility owners for damages caused by interference with the use of their nearby homes. . . .

No reasonable fact finder could conclude that in the real estate marketplace, a potential buyer would not notice, and react economically, to having a large hog facility very nearby while living in a remote location.

~*Livingston v. Jefferson County Bd. of Equalization*, 640 N.W.2d 426, 431, 437 (Neb. Ct. App. 2002).

In another Nebraska tax case, the state Supreme Court held that an assessor's valuation was "arbitrary and unreasonable" because it did not apply external/locational depreciation to a home that was near a cattle feedlot. The property owner provided testimony about problems with dust, trucks, and flies from the nearby feedlot. In addition, the well for the home was connected to the cattle-watering facility.

~ *Darnall Ranch, Inc. v. Banner County Bd. of Equalization*, 753 N.W.2d 819, 830-32 (Neb. 2008).

In a 1999 South Dakota case, the Court upheld the decision of a land commission to deny a permit for the siting of a hog confinement facility based on, among other things, devaluation of surrounding real estate.

~ *Coyote Flats, LLC v. Sanborn County Comm'n*, 596 N.W.2d 347, 352, 356 (S.D. 1999).

An appellate court in Illinois has recognized that factory farms can decrease neighboring property values. In *Nickels v. Burnett*, the Court upheld a preliminary injunction against building an 8,000-head hog CAFO based in part on "extensive evidence in the form of affidavits and scholarly articles authored by the expert affiants demonstrating that, if the hog facility were to begin operation, plaintiffs would experience substantially harmful health effects and a significant loss of value to their land." The Court found the "harms described were substantially certain to occur should the hog facility begin operations in its present proposed location."

The neighboring plaintiffs alleged that the facility would devalue their properties (among other things). The plaintiffs introduced the affidavit of a professional appraiser, who stated that neighboring property values would be reduced by 18-35%. They also presented affidavits from two doctors who concluded, respectively, that "years of downwind exposure to Hydrogen Sulfide even in low doses can cause permanent brain damage and . . . any exposure must be avoided;" and that "locating the proposed hog facility 3/4 of a mile or less away from homes is likely to cause medical and psychological symptoms to the people living in those homes." Another expert opined that "subjecting the Schmidt and Klein families (the families living closest to the site of the proposed hog operation), to the hog operation odors will significantly increase the likelihood that the two families will experience health problems and that it will cause significant detrimental effects on the quality of their lives." In his opinion, "subjecting the other 13 families, whose homes are located within 3/4 of a mile from the proposed hog operation, to the emissions generated by the proposed hog operation will increase their risk of health problems."

~ *Nickels v. Burnett*, 798 N.E.2d 817, 820, 826 (Ill. App. Ct. 2003); Brief of Appellees at 7-10.

In Pasco, Washington, an appraisal done for litigation purposes found an over 50% reduction in value of a family farm impacted by neighboring CAFO dust, flies, fecal matter, and odor. The CAFO settled the lawsuit by relocating the plaintiffs and buying their farm.

~ John A. Kilpatrick, *Concentrated Animal Feeding Operations and Proximate Property Values*, 39:3 Appraisal J. 301, 305 (2001).

In Michigan, a horse farm appealed its property tax assessment because it was located near a large scale pork processing facility. The horse farm got a 50% reduction based on airborne externalities and flies.

~ John A. Kilpatrick, *Concentrated Animal Feeding Operations and Proximate Property Values*, 39:3 Appraisal J. 301, 305 (2001).

In a 2002 Iowa nuisance case, the Court ordered a pork company to pay \$100,000 to homeowners when their home dropped \$50,000 in value after a nearby CAFO was built. The plaintiffs had alleged that the CAFO attracted bugs and harmed their physical and emotional health.

~ Associated Press, *Judge Awards Iowa Couple \$100,000 in Hog Lot Lawsuit*, Amarillo Globe-News, Jan. 12, 2002.

In 1998 in Cedar County, Nebraska, property owners received an assessment reduction based on a neighboring CAFO. On the protest form to the tax board, the property owners stated: "Our neighbor has built a hog confinement and lagoon across the road from our house. This same neighbor has runoff from his cattle yards in to the road ditch 100ft from our well. The nitrates in our water ha[ve] increased making it not safe to drink. We feel a valuation increase of \$35,340 is unfair." The board looked at the property and decided to assess a 25% locational depreciation.

~ Great Plains Environmental Law Center, Case Studies, Cedar County, Property Valuation Protest Form (1998).

In January 2002, in Calhoun County, Iowa, a jury awarded \$76,400 in damages to four property owners who claimed a 4,000-hog operation within a mile of their properties diminished their property values. In another Iowa county, a Court had recently awarded \$100,000 to other property owners for decreased property values from a nearby hog feeding operation.

~ Jerry Perkins, *Jury Sides against Hog-lot Firm: A Total of \$76,400 Will Go to Residents Near the Facility*, Jan. 26, 2002.

A 1998 newsblurb from Kansas reported that a jury awarded \$15,000 to retired farmers who live near a feedlot for diminished property values and loss of peace of mind.

~ *Across the USA: News from Every State*, USA Today, June 22, 1998.

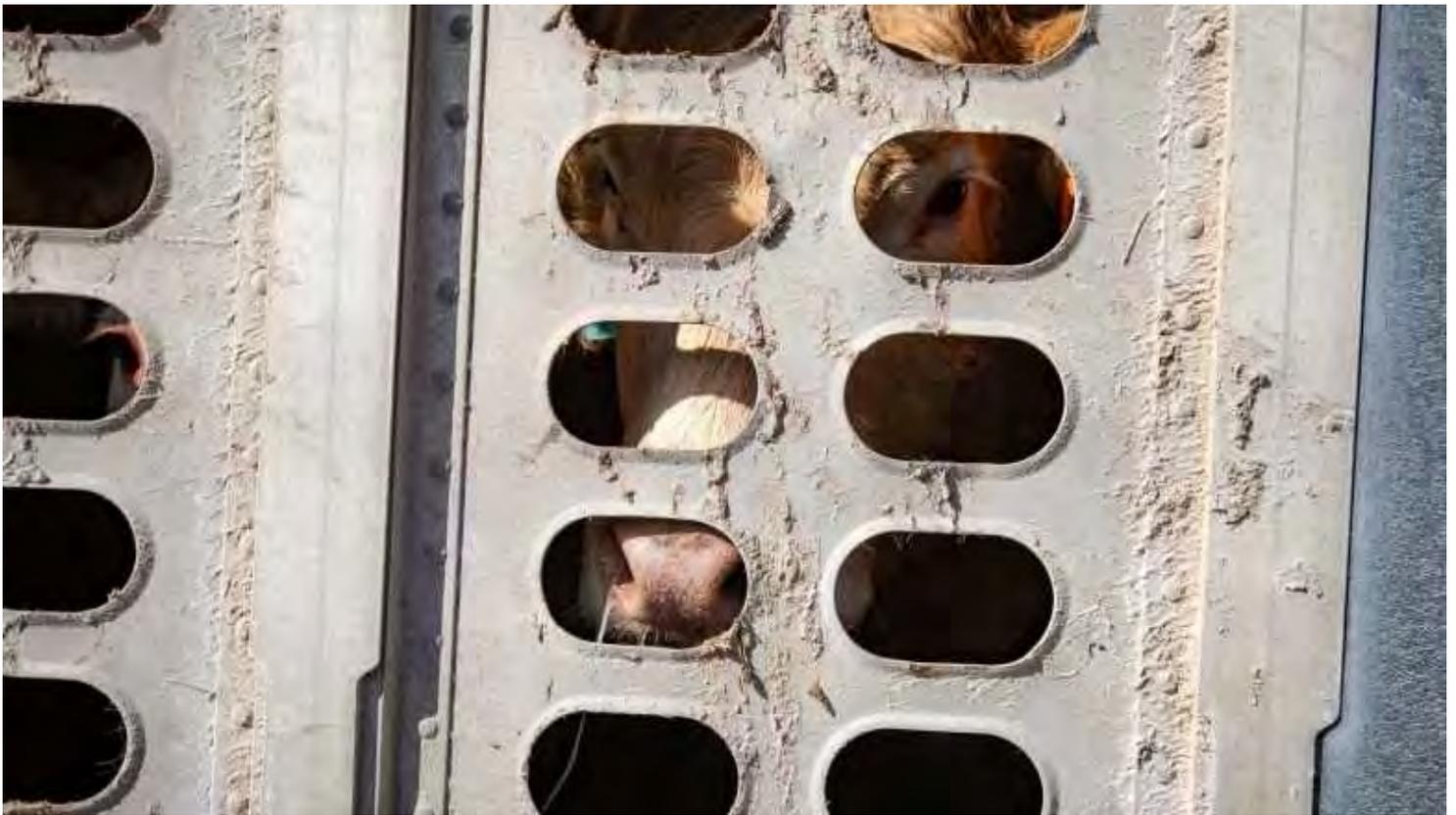
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Toronto

## Residents, politicians 'disturbed' by new meat-processing plant in Toronto neighbourhood

'Not fair' that community wasn't consulted, city councillor says

CBC News · Posted: Feb 26, 2021 7:15 PM ET | Last Updated: February 26



Cows in a truck await transport into a meat processing plant in Toronto's Stockyards neighbourhood on Friday. (Evan Mitsui/CBC)

Residents and politicians are speaking out about the possible health and safety risks posed by a new meat processing plant set to open on Monday in a west-end Toronto neighbourhood.

TruHarvest Meats, at 70 Glen Scarlett Rd., is set to open March 1 in Toronto's Stockyards District. The space, located near Weston Road and St. Clair Avenue, was previously occupied by Ryding-Regency Meat Packers before the Canadian Food Inspection Agency (CFIA) cancelled their operating licence in 2019.

David Beveridge said he and other residents living near the site believe the reopening of the new slaughterhouse will make the area "unsafe."

"The big problem in the neighbourhood is right smack in the middle of all of this is a couple of slaughterhouses," Beveridge said.

The new facility also has additions that will make it one of the largest meat processing plants in Ontario.

- [CFIA cancels licences of 3 companies in massive meat recall](#)

According to federal records, there were numerous food recalls related to E.coli in various products coming out of the former plant. During the investigation, it was noted that the company was non-compliant and provided false or misleading information to investigators.

CBC Toronto reached out repeatedly for comment from both TruHarvest and Ryding Regency on Friday, but has received no response.





TruHarvest Meats will process beef and veal in the former Ryding Regency facility, which was shut down over food safety violations in 2019. (Evan Mitsui/CBC)

Beveridge moved his family to the area just four years ago. He said he was drawn to the neighbourhood by its affordable housing at the time. He bought a house during the winter and quickly discovered with warmer weather, also came an "unreasonable" smell.

"The smell of blood, the smell of the cattle being driven through the neighbourhood," he said.

***WATCH | Residents are concerned about a meat processing plant set to open Monday in their west-end neighbourhood***



Residents are concerned as a new meat packing plant expects to open in the Stockyards on March 1

8 months ago | 2:04

Some residents in the Stockyards neighbourhood are concerned about the new meat processing plant expected to open in their neighbourhood. Jessica Ng spoke to residents of the area. 2:04

"It's not a farm smell, it is a slaughterhouse smell."

While the foul smell is a common complaint amongst residents, Beveridge said the real concern is the safety risk the new plant imposes on many families in the neighbourhood.

Beveridge is worried about the effect the plant on his two kids: a four-year-old and an 18-month-old.

"They have been cited in the past and they tell us they have filters on the smoke stacks coming out of it, but I don't know what's coming out of that and how far it's drifting," he said.

"It's becoming unsafe, the way it is right now."

Beveridge said tractor trailers turning onto residential streets and parking on sidewalks pose a risk for families with young children in the area.



David Beveridge, who has a four-year-old and an 18-month-old, moved into Toronto's Stockyards neighbourhood four years ago and says the new slaughterhouse poses a safety risk to the community. (Submitted by David Beveridge)

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Coun. Frances Nunziata, who represents Ward 5, York South-Weston, said she is also concerned by TruHarvest taking over the plant.

"This is a privately-owned facility on private land and my office has not been involved in any conversations about the use of this site as is currently permitted," Nunziata said in a statement dated Feb. 19.

Nunziata said it is unfair that residents were not consulted.

"With the federal government and provincial government, they can issue licences and there's no consultation, which is unfortunate because I don't think that's fair. But that's what's happened," Nunziata told CBC Toronto on Friday.

- ['It still stinks!': Residents have mixed opinions on city efforts to curb Humber, Ashbridges sewage smells](#)

The land has been in the process of being rezoned for years, she said, but its use must be discontinued in order to proceed.

Faisal Hassan, NDP MPP for York South-Weston, echoed those concerns, saying residents are "disturbed" after learning the news.

"Our office has been inundated with emails and calls objecting to this facility," Hassan said Thursday at Queen's Park.

He questioned why residents were not consulted before the company took over operations at the facility.

According to federal records, there were numerous food recalls related to E.coli in various products coming out of Ryding Regency Meat Packers, the company that formerly operated out of the facility. (Evan Mitsui/CBC)

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"The previous slaughterhouse was closed and had its licence revoked due to many health and environmental violations. An environmental compliance approval was granted to the former owners despite nearly 100 complaints and public consultations in 2018," he said.

"How did this new facility get approved and why was the community not consulted?"

Animal rights activists, who are calling for the the plant to be shut down, plan to hold a a vigil outside the plant Monday morning and a demonstration outside CFIA offices following that.

"During this time of global uncertainty, it's more important than ever that elected officials consider the best interests of the population, taking the necessary steps to reduce the impact of this global health emergency and prevent future illness," said Jenny McQueen, organizer with Animal Save Movement, in a statement Thursday.

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*With files from Jessica Ng*

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COVID19

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## Will COVID-19 help save small slaughterhouses?

*As laborers for the Big Four meatpackers fall ill, small slaughterhouses see unprecedented demand.*

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**Carl Segerstrom** | May 20, 2020 | *From the print edition* |

PRINT

*As a service to readers, High Country News has removed the paywall from all COVID-19 stories. Please consider supporting our work by donating, subscribing or sending us tips.*

A recently closed small slaughterhouse in Odessa, Washington, is in the process of reopening, thanks to soaring demand for locally raised and processed meat. As large meatpacking facilities across the country have become hotspots for COVID-19 outbreaks — at least 277 cases have been confirmed among the nearly 1,500 workers at the Tyson Foods plant 100 miles south in Wallula, Washington, and three people have died — business is booming for small meatpackers.

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With grocery stores limiting customer purchases, some Wendy's restaurants running out of beef and the price of ground beef increasing near Right Country News from March to April, customers are flocking to ranchers like Ed Gross, who has a herd of 1,500 cattle in eastern Washington. "Even big chain stores are looking to buy from us now," said Gross, one of the founders of the Odessa plant.

Big meatpacking facilities have made meat cheap in the United States. But those low prices have come at a cost to workers and pushed smaller slaughterhouses out of business. Now, as people turn to small butchers for meat, the pandemic is exposing the vulnerability of this centralized system — and highlighting the importance of a diverse and resilient food economy.



### The Big Four Meatpackers

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The meatpacking industry has undergone major consolidation. From 1990 to 2016, the U.S. lost more than 1800 livestock slaughterhouses, 40% of the industry. As small slaughterhouses closed, the so-called "Big Four" meatpacking companies — Tyson, Cargill, JBS and National Beef — came to dominate the industry.

Today, these four companies process more than 80% of beef in the U.S.

In 2013, the Livestock Processor's Cooperative Association, a group of ranchers in eastern Washington, tried to break the grip of industry consolidation by opening a slaughterhouse in Odessa, Washington. The plant, which was backed by

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community development agencies, would allow ranchers to tap into consumer demand for local beef without transporting cattle long distances

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Right Country News

fighting or using large meat

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But the cooperative struggled with inconsistent sales and hiring and retaining employees in a small town, Gross said. Now, however, with the pandemic driving demand and closing the price gap between local and industrial beef, the Odessa facility is preparing to reopen in June.



*Ken Wilke and his son, Jeff Wilke, skin a cow at a client's farm in 2011. The family's company, Quadra-K Meats, serves people who raise their own animals. With large meatpacking plants closing down, demand for small butchers has skyrocketed.*

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*Young Kwak*

Jeff Wilke, a butcher on the outskirts of Spokane, Washington, who works directly with animal owners, is also seeing unprecedented consumer interest — so much so, that he's booked up for the rest of the year. "My phone's been ringing off the hook," Wilke said.

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# “Animals don’t get poked and prodded and loaded onto semis”

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Wilke’s business, Quadra K-Meats, serves people who are raising their own animals and ranchers who sell directly to consumers. Wilke slaughters animals where they were raised, something he’s done since he was a kid, helping out his dad in the 1970s. “Animals don’t get poked and prodded and loaded onto semis,” he said.

But that process isn’t nearly as efficient as industrial operations: The assembly lines at large meatpacking facilities can process hundreds of cattle an hour, while Wilke slaughters and processes about eight animals a week. That means meat processed by small slaughterhouses typically costs more: A locally raised and slaughtered cut of top sirloin steak at the Main Market Co-Op in Spokane costs more than \$14 a pound, while a top sirloin at Walmart in Spokane costs less than half that.

Slaughterhouses like Wilke’s also confront a two-tiered system of slaughterhouse certification. Most large facilities — and some smaller ones, including the Odessa plant — are inspected by U.S. Department of Agriculture or state inspectors and permitted to sell individual cuts to stores and restaurants. Businesses like Wilke’s, however, don’t have inspectors on site and can only process animals that were purchased directly from individual ranchers.

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*Jeff Wilke prepares to shoot a cow at a client's property in Spokane County, Washington. Wilke slaughters animals where they were raised, instead of putting them through a stressful journey to an industrial slaughterhouse.*

*Young Kwak*

That lack of access to venues like farmers markets makes it harder for small slaughterhouses to stay in business. In response, federal lawmakers have introduced a bipartisan bill several times in recent years. The PRIME Act would make it easier for butchers who aren't USDA-inspected to reach customers by allowing them to sell meat to restaurants and other retail outlets.

Without such reforms, the current bump in business for small processors may not last. Right now, it's time to "make hay while the sun shines," said Rebecca Thistlethwaite, an agricultural extension agent for Oregon State University and the director of the Niche Meat Processor Assistance Network. But with the potential for a prolonged economic slump following the

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pandemic, she expects that most people will soon return to cheaper meat processed at large facilities, as happened during the 2008 recession

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That would further the long-term decline of small slaughterhouses and ranching operations, leaving the meat industry even more consolidated and vulnerable to future disasters. The COVID-19 pandemic has exposed the risk of relying on just a handful of companies and factories to keep grocery stores full. A diverse system composed of businesses from large to small is key to making the food supply resilient, Thistlethwaite said. “People are realizing that now,” she said. “Hopefully, we can continue to support small producers going forward.”

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*Carl Segerstrom is an assistant editor at High Country News, covering Alaska, the Pacific Northwest and the Northern Rockies from Spokane, Washington. Email him at [carls@hcn.org](mailto:carls@hcn.org) or submit a letter to the editor.*

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# Slaughterhouse Wastewater Treatment by Combined Chemical Coagulation and Electrocoagulation Process

Edris Bazrafshan, Ferdos Kord Mostafapour, Mehdi Farzadkia, Kamal Aldin Ownagh, Amir Hossein Mahvi

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## Abstract

Slaughterhouse wastewater contains various and high amounts of organic matter (e.g., proteins, blood, fat and lard). In order to produce an effluent suitable for stream discharge, chemical coagulation and electrocoagulation techniques have been particularly explored at the laboratory pilot scale for organic compounds removal from slaughterhouse effluent. The purpose of this work was to investigate the feasibility of treating cattle-slaughterhouse wastewater by combined chemical coagulation and electrocoagulation process to achieve the required standards. The influence of the operating variables such as coagulant dose, electrical potential and reaction time on the removal efficiencies of major pollutants was determined. The rate of removal of pollutants linearly increased with increasing doses of PACl and applied voltage. COD and BOD<sub>5</sub> removal of more than 99% was obtained by adding 100 mg/L PACl and applied voltage 40 V. The experiments demonstrated the effectiveness of chemical and electrochemical techniques for the treatment of slaughterhouse wastewaters. Consequently, combined processes are inferred to be superior to electrocoagulation alone for the removal of both organic and inorganic compounds from cattle-slaughterhouse wastewater.

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## Introduction

Wastewater from a cattle slaughterhouse is a mixture of the processing water from both the slaughtering line and the cleaning of the guts, which causes a large variation in the concentration of organic matter. The main pollutant in slaughterhouse effluents is organic matter. The contributors of organic load to these effluents are paunch, feces, fat and lard, grease, undigested food, blood, suspended material, urine, loose meat, soluble proteins, excrement, manure, grit and colloidal particles [1], [2].

Untreated slaughterhouses waste entering into a municipal sewage purification system may create severe problems, due to the very high biological oxygen demand (BOD) and chemical oxygen demand (COD) [3]. Therefore treating of slaughterhouse wastewater is very important for prevention of high organic loading to municipal wastewater treatment plants. The most common methods used for treating slaughterhouse wastewaters are fine screening, sedimentation, coagulation–flocculation, trickling filters and activated sludge processes.

The treatment of slaughterhouse wastewater by various methods such as aerobic and anaerobic biological systems [4], [5], [6], [7] and hybrid systems [2] have been intensively studied. Aerobic treatment processes are limited by their high energy consumption needed for aeration and high sludge production. Also, the anaerobic treatment of slaughterhouse wastewater is often slowed or impaired due to the accumulation of suspended solids and floating fats in the reactor which lead to a reduction in the methanogenic activity and biomass wash-out. In addition, it is also reported that anaerobic treatment is sensitive to high organic loading rates, as a serious disadvantage [8]. Even though biological processes are effective and economical, both biological processes require long hydraulic retention time and large reactor volumes, high biomass concentration and controlling of sludge loss, to avoid the wash-out of the sludge. Among physico-chemical processes, dissolved air flotation (DAF) and coagulation–flocculation units are widely used for the removal of total suspended solids (TSS), colloids, and fats from slaughterhouse wastewaters [1].

Chemical coagulation of slaughterhouse wastewater has also been studied by adding aluminum salts and polymer compounds, and a maximum COD removal efficiency of 45–75% has been reported [9], [10]. Polyaluminum chloride (PACl) is commonly used as the flocculant to coagulate small particles into larger flocs that can be efficiently removed in the subsequent separation process of sedimentation and/or filtration. Much attention has been paid to PACl in recent years because of its higher efficiency and relatively

low costs compared with the traditional flocculants [11], [12]. On the other hand, PACl has become one of the most effective coagulant agents in water and wastewater treatment facilities with various applications, including removal of colloids and suspended particles, organic matter, metal ions, phosphates, toxic metals and color [13].

Recently, electrochemical methods such as electrooxidation [14] and electrocoagulation have been widely used as an attractive and suitable method for the treatment of various kinds of wastewater such as poultry and cattle slaughterhouse wastewater and wastewaters contain heavy metals, by virtue of various benefits including environmental compatibility, adaptability, energy efficiency, safety, selectivity, amenability to automation, and cost effectiveness [15], [16], [17], [18], [19], [20]. An examination of the chemical reactions occurring in the electrocoagulation process shows that the main reactions occurring at the electrodes (aluminum electrodes) are:



In addition,  $\text{Al}^{3+}$  and  $\text{OH}^{-}$  ions generated at electrode surfaces react in the bulk wastewater to form aluminum hydroxide:



The aluminum hydroxide flocs normally have large surface areas which are beneficial for a rapid adsorption of soluble organic compounds and trapping of colloidal particles [15], [16], [21]. Also, these flocs polymerize further and are removed easily from aqueous medium by sedimentation or/and flotation by hydrogen gas.

Chemical coagulation using PACl and electrocoagulation process with aluminum electrodes of wastewater from a cattle slaughterhouse is described in this article. The purpose of this work was to investigate the feasibility of treating cattle-slaughterhouse wastewater by combined chemical coagulation and electrocoagulation process separately to achieve the required legal direct-discharge limit of COD and  $\text{BOD}_5$  which is 60 and 30 mg/L in Iran for the slaughterhouse industry effluents. The influence of the operating variables such as coagulant dose, pH, applied voltage and reaction time on the removal efficiencies of major pollutants was also determined. Information regarding the electrical energy consumption (EEC) is also included to provide an estimation of the cost of pollutants removal by an electrocoagulation system.

## Results and Discussion

### Wastewater characterization

Table 1 presents the slaughterhouse wastewater characteristics prior to any treatment, after 24 h settling time and the guidelines from Iran for effluent discharge in the sewage urban works. The values of the pollution parameters were lowered after 24 h of preliminary settling time. Also, the comparison of these values showed that, the COD,  $\text{BOD}_5$ , microbial indicators (Total and Fecal Coliforms) and the concentration of Oil and grease were very greater than those recommended by Iran. Consequently, the slaughterhouse effluent needed to be treated before discharge.

**Table 1. Characteristics of the experimental cattle slaughterhouse wastewater.**  
<https://doi.org/10.1371/journal.pone.0040108.t001>

### Effect of preliminary settling time

Preliminary settling process is a natural treatment method that requires no chemical addition. Although some workers realized the importance of the natural settling process, there is little information available in the literature on the effect of the preliminary settling time on TSS removal capacity [22]. Most studies carried out on the treatment of slaughterhouse wastewater were based on diluted pre-settled wastewater [23].

In this study, the raw slaughterhouse wastewater was allowed to settle for 24 h in a preliminary settling tank before the addition of a coagulant. The process had an effect on  $\text{BOD}_5$ , COD, TSS, TKN and coliform bacteria removals on the first 24 h. TKN concentration reduced from  $137 \pm 12$  to  $92 \pm 12$  mg/L (on average 33% TKN removal efficiency), COD concentration reduced from  $5817 \pm 473$  to  $4159 \pm 281$  mg/L (approximately 28% COD removal efficiency) whereas  $\text{BOD}_5$  was reduced in the wastewater from  $2543 \pm 362$  to  $2204 \pm 177$  mg/L (about 13%  $\text{BOD}_5$  removal efficiency). Furthermore, TSS concentration was reduced to  $1172 \pm 84$  mg/L (approximately 64% TSS removal efficiency). Similar results were reported by Amuda and Alade [10].

Also, data revealed that the effluent of the settling unit is characterized by high load of organic matter. The ratio  $\text{BOD}_5/\text{COD}$  of approximately 0.5, indicates that 50% of the COD of this wastewater is easily able to be degraded by biological treatment. Nevertheless, the remainder COD is high, which indicates the necessity of an efficient physicochemical treatment for this wastewater.

### Effect of coagulation process (first step)

Coagulation/flocculation experiments using PACI as coagulant in the jar test were performed to investigate the effect of coagulation process in the removal efficiencies of COD, BOD<sub>5</sub>, TSS, TKN and coliform bacteria. Therefore, PACI was added to the slaughterhouse wastewater to achieve particle instability and increase in the particle size, consequently achieving effective removal of organic substances present as COD and BOD<sub>5</sub>. The doses of PACI as coagulant were varied between 0 and 100 mg/L to determine the optimum dose of PACI for pollutants removal. The results of jar-tests using the PACI individually are presented in [Table 2](#) and [Figure 1](#). It is shown that at lower doses of the PACI (25 mg/L), COD, BOD<sub>5</sub>, TSS and TKN removal efficiency reached a maximum of 37%, 31%, 47% and 27%, respectively. Aguilar et al. [24] reported TKN removal efficiency 50–60% by using PACI as coagulant from slaughterhouse wastewater. Also, Amuda and Alade [10] were reported maximum removal efficiency 65% and 34% of COD and TSS using a 750 mg/L dose of alum as coagulant in abattoir wastewater treatment.

**Figure 1. Effects of coagulant dose (PACI) on pollutants removal efficiency at pilot scale coagulation process.**  
<https://doi.org/10.1371/journal.pone.0040108.g001>

**Table 2. Influence of PACI dosage on water quality parameters of coagulated mixed liquor (mean values).**  
<https://doi.org/10.1371/journal.pone.0040108.t002>

As it shown in [Figure 1](#), the efficiency of the process increased with increasing dosages of coagulant (PACI). The curve obtained with PACI points to a considerable increase in performance from the lowest dose up to 100 mg/L. On the other hand in chemical coagulation, as seen in [Figure 1](#), an increase in COD, BOD<sub>5</sub>, TSS, TKN and other pollutants removal efficiency is noted with increasing PACI dosage, reaching nearly 40–60% for PACI dosage of 100 mg/L. Al-Mutairi et al. [9] reported that suspended solids and turbidity removal from slaughterhouse wastewater increased substantially as the alum (as coagulant) dosage is increased. Also, [Figure 1](#) shows that the TSS removal and COD and BOD<sub>5</sub> reduction trends are similar to each other. This may be due to the high organic contents of the suspended solid particles.

Maximum TC and FC removal efficiency of >99.9% ([Table 2](#)) were obtained by using PACI at the dosage of 100 mg/L. The TC and FC reduction, increase with increase in coagulant dosage.

TC indicator of effluent with coagulant dose 25 mg/L PACI was reduced from  $2.3 \times 10^9$  to  $2.8 \times 10^7$  (MPN/100mL) (approximately more than 98% TC removal efficiency), and by increasing the coagulant dose to 100 mg/L, the TC indicator of effluent was decreased was reduced from  $1.7 \times 10^8$  to  $1.6 \times 10^6$  (MPN/100mL) (on average more than 99% TC removal efficiency) that is much more than permissible level. A similar reduction trend was determined for FC indicator. Similar results were obtained in previous reports concerning the electrocoagulation of wastewater from vegetable oil refinery wastewater using aluminum electrodes (with adding PACI as coagulant aid) [19].

According the results of this study ([Table 2](#)) it can be concluded that although the efficiency for removal of most parameters from slaughterhouse wastewater are high, but the concentration of pollutants in effluent of chemical coagulation process does not meet the effluent discharge standards to the environment. Thus, the effluent from conventional coagulation should be preceded by another treatment process to be completed. For this purpose, in this research, electrocoagulation was employed as a completion of treatment process to obtain discharge standards.

#### Effect of electrocoagulation process (second step)

Electrocoagulation processes a direct current source between metal electrodes immersed in wastewater. The electrical current causes the dissolution of metal electrodes commonly iron and aluminum into wastewater. The dissolved metal ions, at an appropriate pH, can form wide ranges of coagulated species and metal hydroxides that destabilize and aggregate the suspended particles or precipitate and adsorb dissolved contaminants [25], [26].

As be mentioned earlier, an examination of the chemical reactions occurring in the electrocoagulation process shows that the main reactions occurring at the aluminum electrodes are:

(4)

(5)

(6)

monomeric species such as  $\text{Al}(\text{OH})_2^{2+}$ ,  $\text{Al}(\text{OH})_2^+$ ,  $\text{Al}_2(\text{OH})_2^{4+}$ ,  $\text{Al}(\text{OH})_4^-$  and polymeric species such as  $\text{Al}_6(\text{OH})_{15}^{3+}$ ,  $\text{Al}_7(\text{OH})_{17}^{4+}$ ,  $\text{Al}_8(\text{OH})_{20}^{4+}$ ,  $\text{Al}_{13}\text{O}_4(\text{OH})_{24}^{7+}$ ,  $\text{Al}_{13}(\text{OH})_{34}^{5+}$  are formed during the electrocoagulation process [26], [27]. The aluminum hydroxide flocs act as adsorbents and/or traps for pollutants and so eliminate them from the solution [28], [29].

As mentioned earlier, the performances by the two pretreatment, namely, preliminary settling and chemical coagulation, were not carried out efficiently enough to satisfy the national guideline of effluent qualities. Additional dosage of coagulant (PACl) and longer time were needed to keep the national guideline of the effluent qualities. Therefore, the electrocoagulation process was employed as the final treatment step in this study. In adopting the electrocoagulation process, it was intended to treat the pollutant efficiently as well as economically.

The effects of applied voltage and reaction time on electrocoagulation process of slaughterhouse wastewater treatment were determined. The results of the effects of operating parameters on pilot scale electrocoagulation process are shown in [Table 3](#) and [Figures 2, 3, 4, and 5](#).

**Figure 2. Effect of applied voltage on pollutants removal efficiency (coagulant dose: 25 mg/L, reaction time: 60 min).**  
<https://doi.org/10.1371/journal.pone.0040108.g002>

**Figure 3. Effect of applied voltage on pollutants removal efficiency (coagulant dose: 50 mg/L, reaction time: 60 min).**  
<https://doi.org/10.1371/journal.pone.0040108.g003>

**Figure 4. Effect of applied voltage on pollutants removal efficiency (coagulant dose: 75 mg/L, reaction time: 60 min).**  
<https://doi.org/10.1371/journal.pone.0040108.g004>

**Figure 5. Effect of applied voltage on pollutants removal efficiency (coagulant dose: 100 mg/L, reaction time: 60 min).**  
<https://doi.org/10.1371/journal.pone.0040108.g005>

**Table 3. Influence of electrocoagulation process using aluminum electrodes on effluent quality parameters (mean values).**  
<https://doi.org/10.1371/journal.pone.0040108.t003>

#### Effect of applied voltage

One of the most important parameter influencing the performance and economy of the electrocoagulation process is the applied voltage at the electrodes [30]. To understand the effect of applied voltage on the efficiency of electrocoagulation process in treating of slaughterhouse wastewater, several voltages in the range of 10 to 40 V were applied between the electrodes in the electrocoagulation cell, and pollutants removal was determined at the conditions given in [Table 3](#).

The applied voltage is expected to exhibit a strong effect on electrocoagulation, especially on the COD abatement: higher the current (voltage), shorter the treatment. The supply of current to the electrocoagulation system determines the amount of  $Al^{3+}$  ion released from the respective electrodes and the amount of resulting coagulant. Thus, more  $Al^{3+}$  ion get dissolved into the solution and the formation rate of  $Al(OH)_3$  is increased. Also, it is well-known that electrical potential not only determines the coagulant dosage rate but also the bubble production rate and size and the flocs growth [31], [32], which can influence the treatment efficiency of the electrocoagulation process.

As it can be seen from [Table 3](#) and [Figures 2, 3, 4, and 5](#), the removal efficiency of pollutants is very high and as expected, it appears that for a given time, the removal efficiency increased significantly with increase of electrical potential. As the results shown in [Table 3](#) and [Figures 2, 3, 4, and 5](#), the removal efficiencies increased as the electrical potentials are increased. As an example, COD concentration of chemical coagulation process with 25 mg/L PACl has decreased from 2643 to 555 mg/L (approximately 79% COD removal efficiency) after electrocoagulation process with electrical potential of 10 V. Again, by increasing electrical potential to 40 V, the COD concentration in the effluent decreased to 108 mg/L in 60 min (approximately 96% COD removal efficiency). In addition, the COD of effluent from chemical coagulation with 100 mg/L PACl, was decreased to about 294 mg/L (approximately 83% COD removal efficiency) by electrocoagulation process with electrical potential of 10 V, and by increasing the electrical potential to 40 V, the COD of effluent was decreased to less than 13 mg/L (on average more than 99% COD removal efficiency) that is lower than permissible level.

According to the results of [Table 3](#), and [Figures 2, 3, 4, and 5](#), TKN of chemical coagulation process with 25 mg/L PACl was reduced to lower than 50 mg/L after electrocoagulation process with electrical potential of 10 V (approximately 65% TKN removal efficiency), and by increasing electrical potential to 40 V, the TKN concentration in the effluent decreased to 26 mg/L (about 81% TKN removal efficiency). Furthermore, with increase in coagulant dose to 100 mg/L and increase of applied voltage to 40 V, TKN concentration in effluent was reduced to lower than 7 mg/L (on average 94% TKN removal efficiency). A similar trend was seen for TSS and BOD<sub>5</sub> parameters.

Also, as can be seen from [Table 3](#), the removal efficiency of bacterial indicators (TC and FC) is very high and efficiency was increased with increase in applied voltage from 10 to 40 V. Maximum removal efficiency (>99.9%) was obtained in applied voltage 40 V (coagulant dosage 100 mg/L), and thus the effluent quality was reached to permissible levels (lower than 1000 and 400 for TC and FC, respectively) and hence discharge of this effluent to environment is safe. Also, minimum removal efficiency occurred in the lowest electrical potential (10 V). This is ascribed to the fact that at high voltage, the amount of aluminum oxidized increased, resulting in a greater amount of precipitate for the removal of pollutants. In addition, it was demonstrated that bubbles density increases and their size decreases with increasing current density [33], resulting in a greater upwards flux and a faster removal of pollutants and sludge flotation. As be mentioned earlier, the main mechanisms for removal of pollutants in this process are rapid adsorption of soluble organic compounds and trapping of colloidal particles in "sweep flocs" (Al(OH)<sub>3</sub>). Nevertheless, Bayar et al. [34] was reported that increase in the current density does not cause an expected removal efficiency increase; on the contrary, it can cause a relatively negative effect on it. Also, a similar trend was seen in the study of Holt et al. [32].

#### Electrical energy and electrode consumption

Electrical energy consumption is a very important economical parameter in the electrocoagulation process. Therefore, for the same operating conditions, after 60 min of electrocoagulation, consumption of energy and aluminum electrode is also represented in [Figures 6 and 7](#). The electrical energy consumption was calculated using the related equations [35].

**Figure 6. Electrical energy consumption during coagulation-electrocoagulation process (kWh/L).**  
<https://doi.org/10.1371/journal.pone.0040108.g006>

**Figure 7. Electrode consumption during chemical coagulation-electrocoagulation process.**  
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It can be understood from [Figures 6 and 7](#) that electrical energy and electrode consumption were found to increase with increasing the applied voltage as would be expected in any other electrolytic process. An increase in applied voltage from 10 to 40 V causes an increase in energy consumption from about 0.001 to 0.08 kWh/L and from 0.011 to approximately 0.09 kWh/L for 25 and 100 mg/L of coagulant dosage (PACl), respectively. A similar trend was seen in the study of Bayar et al. [34] on Poultry slaughterhouse wastewater treatment by electrocoagulation method.

Also, as shown in [Figure 7](#), an increase in applied voltage from 10 to 40 V causes an increase in electrode consumption from about 0.41 to 1.23 g/L and 0.51 to 1.3 g/L of pollutants for 25 and 100 mg/L of PACl, respectively. This result is in agreement with the results obtained by Bazrafshan et al. [36], [37], [38].

When the applied voltage was increased from 10 V to 40 V, the COD and BOD<sub>5</sub> removal efficiency increased appreciably, to more than approximately 99%, whereas the corresponding specific energy consumption increased only slightly. Therefore, in present study, 40 V is chosen as optimum operating voltage for electrocoagulation process.

#### Conclusions

In this study, chemical coagulation using Polyaluminum chloride (PACl) and Electrocoagulation process using aluminum electrodes of wastewater from a cattle slaughterhouse was investigated. The effects of the different operational parameters on the removal of pollutants analyzed. The following conclusions can be reached from the results obtained in this work:

- The installation of a good fat separator prior to each biological or chemical treatment unit seemed an appropriate alternative to a chemical coagulation and electrocoagulation process.
- Preliminary settling time were investigated and found to be important operational parameter for effective treatment of slaughterhouse wastewater.
- A preliminary settling time of 24 h had an effect on the BOD<sub>5</sub>, COD, TSS and TKN with removal efficiency up to 14%, 29%, 64% and 33%, respectively.
- According to the results obtained from the present experiments, the removal efficiencies increased by increasing the coagulant dose and electrical potential. At the highest applied voltage, the fastest treatment rate for pollutants (COD, BOD<sub>5</sub>, TSS, TKN and microbial parameters) removal was obtained. Moreover, the energy consumption increased by increasing the applied electrical potential.
- Evaluation of the experimental results indicates that both processes (chemical coagulation and Electrocoagulation) show excellent efficiency at reducing of pollutants.

- Based on this study results, although the coagulation process had high efficiency in removing organic and microbial contaminants, but nevertheless it's not able to meet discharge standards, hence a supplemental process (such as electrocoagulation process) is essential for enhance effluent quality.
- Finally according to the results of this study, it can be concluded that the combined application of chemical coagulation and electrocoagulation processes is able to meet effluent standards for safe discharge to environment.

## Materials and Methods

### Slaughterhouse effluent

The effluent used throughout this study was taken from a local cattle Slaughterhouse plant with 250 cows per day capacity, located in Zahedan City in the province of Sistan and Baluchestan province (Iran), producing approximately 60 m<sup>3</sup> of wastewater daily. The cattle slaughterhouse effluent was sampled after the screening of coarser solids using a filter having a pore size of approximately 2.0 mm and sedimentation for 24 h. Samples were collected in polypropylene bottles, shipped cold, and kept at 4°C before use. The length of the storage before starting experiments varied from one day to six weeks. The effluent has been sampled at different times during this study and the initial characteristics varied with time (Table 1). This effluent initially contained high concentrations of soluble and undissolved organics (4159±81 mg/L COD, 2204±77 mg/L BOD<sub>5</sub>).

### Chemical treatment (coagulation) of slaughterhouse effluent

All the chemicals used in the study were of analytical reagent (AR) grade. Poly- aluminum chloride (PACl) Al<sub>12</sub>Cl<sub>12</sub>(OH)<sub>24</sub> was chosen for this study because it has been used extensively at water and wastewater treatment plants to remove solids and may function as an effective and less expensive coagulant. PACl was used in this study up to 100 mg/L (25, 50, 75 and 100 mg/L). A six-beaker jar test (flocculator) was set up at room temperature for each trial. Each of the beakers contained 2 L of settled wastewater. The coagulants were added into the beakers, and the pH values were immediately adjusted to the preset values (7±0.1) using NaOH or H<sub>2</sub>SO<sub>4</sub> for pH-controlled experiments. Rapid stirring at 150 rpm for 2 min was followed by gentle mixing at 50 rpm for 20 min, and the solids formed were left to settle for 30 min. Samples were taken from the water surface (supernatant) and filtered through 0.45-mm membranes. After chemical coagulation, electrocoagulation process with aluminum electrodes was performed on the supernatant.

### Electrochemical treatment of slaughterhouse effluent

In each run, wastewater (supernatant) after chemical coagulation (first stage of treatment) was poured into the electrocoagulation cell. All experiments were performed in a bipolar batch reactor (Figure 8), with four aluminum electrode connected in parallel. Only the outer electrodes were connected to the power source, and anodic and cathodic reactions occurred on each surface of the inner electrode when the current passed through the electrodes. The internal size of the cell was 15 Cm×15 Cm×25 Cm (width × length × depth) with an effective volume of 2000 Cm<sup>3</sup>. The volume (V) of the solution of each batch was 2 L. The active area of each electrode (plate) was 14×20 Cm with a total area of 280 Cm<sup>2</sup>. The distance between electrodes was 1.5 Cm. A power supply having an input of 220 V and variable output of 0–40 V (10, 20, 30 and 40 V) with maximum current of 5 ampere was used as direct current source. The temperature of each system was maintained at 25±1°C. Different samples of 100 ml were taken at 15 min intervals for up to 1 h and filtered before being analysed to determine BOD<sub>5</sub>, COD, TSS and other parameters. During the runs, the reactor unit was stirred at 150 rpm by a magnetic stirrer to allow the chemical precipitate to grow large enough for removal. During electrocoagulation, an oxide film formed at the anode. In order to overcome electrode passivation at the anode, the electrodes were rinsed in diluted HCl solution (5% v/v) after each experiment and rinsed again with tap water and finally weighted. Also the electrodes reweighted to calculate sacrificial electrode consumptions. These weights are used in the calculations of the total operating cost. In addition, the electrical energy consumed per unit volume of treated wastewater has been calculated for different experimental conditions. All analyses were conducted in duplicate for reproducibility of the experimental results, and all of the data in the Figures and Tables were the average ones.

**Figure 8. The schematic view of coagulation and electrocoagulation reactor.**

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### Analytical

COD, BOD<sub>5</sub>, oil-grease, conductivity, pH, total solids (TS), total suspended solids (TSS), and total Kjeldhal nitrogen (TKN) determinations were determined according to the standard methods [39]. COD was measured using COD reactor and direct reading spectrophotometer (DR/5000, HACH, USA). Five-day biological oxygen demand (BOD<sub>5</sub>) was determined by the manometric method with a respirometer (BSB-Controller Model 620 T (WTW)). Oil-grease was determined with hexane extraction. The pH and conductivity were adjusted to a desirable value using NaOH or H<sub>2</sub>SO<sub>4</sub>, and NaCl, and measured using a pH meter model E520 (Metrohm Herisau, Switzerland) and a Conductivity Meter (Jenway Model 4200), respectively. Also the most-probable-number technique was used for the enumeration of total coliform (TC) and fecal coliform (FC) bacteria [39].

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## Author Contributions

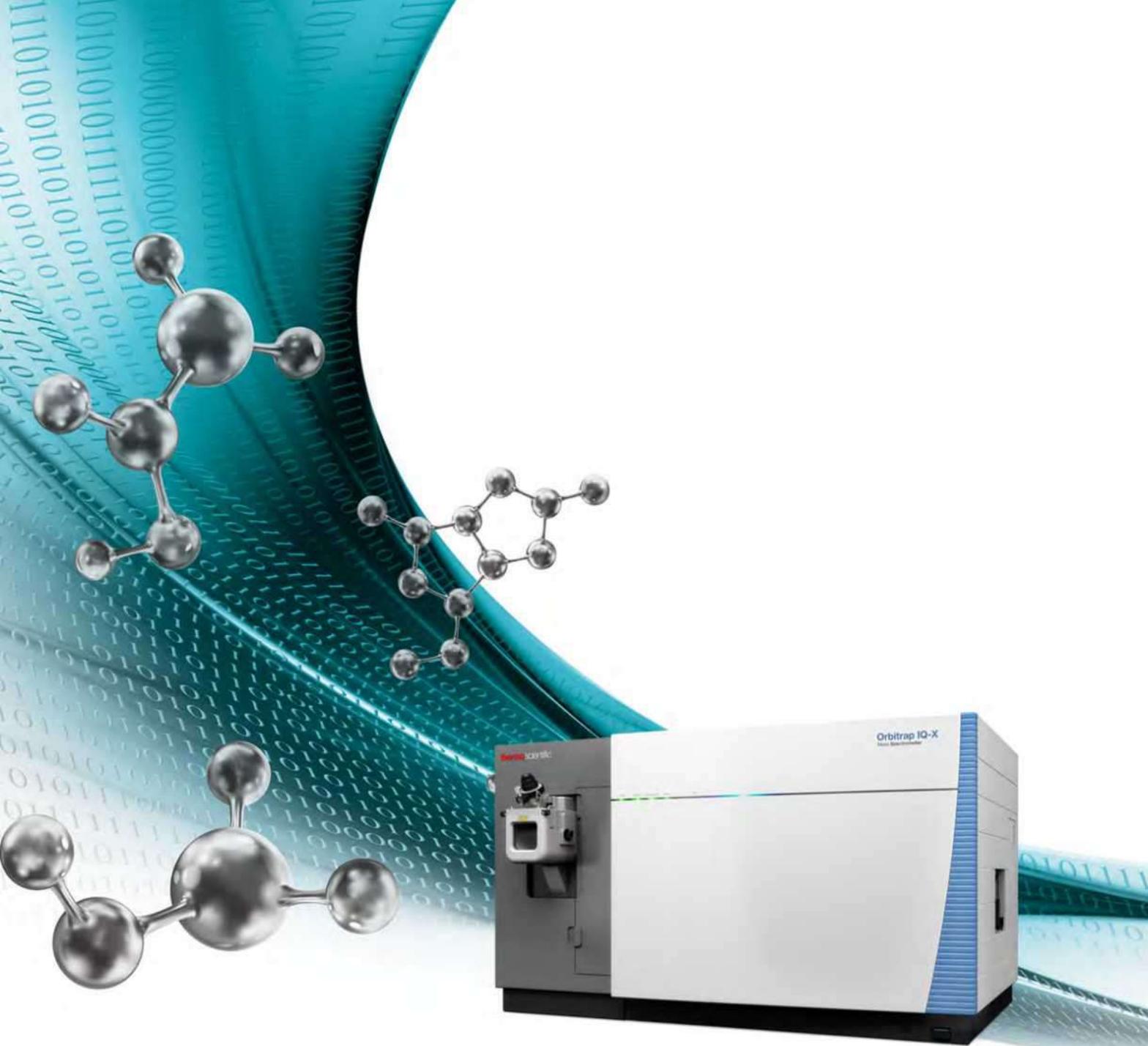
Conceived and designed the experiments: EB AHM. Performed the experiments: EB KAO. Analyzed the data: MF. Contributed reagents/materials/analysis tools: FKM. Wrote the paper: EB AHM.

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# Slaughterhouse Blood: An Emerging Source of Bioactive Compounds

Clara S.F. Bah, Alaa El-Din A. Bekhit, Alan Carne, and Michelle A. McConnell

**Abstract:** Slaughterhouse blood is an inevitable part of the meat production food chain and represents a rich source of protein. The physicochemical characteristics and utilization of animal blood in various food and industrial applications has been well explored. However, in recent years much attention has been paid to the generation of peptides with biological activities from food by-products including blood. This review examines the angiotensin-converting enzyme inhibitory, antioxidant, antimicrobial, and other bioactive peptides derived from various slaughterhouse animal blood sources. Furthermore, the effect of enzyme choice, degree of hydrolysis, and peptide sequence or size on the potency of these bioactivity is discussed.

## Introduction

In the production of food for human consumption, the generation of by-products and waste is an integral part of the production chain. In meat production, the nature and quantity of these materials varies at each stage of production. The products from animals slaughtered for meat may be divided into 4 categories, the first being meat (high-value product), the second is inedible components which can be used for industrial purposes (for example, hides, bones, hooves, and blood), the third is low-value components (offal and meat meal), and, last, items of no useful purpose (for example wool slip, digestive tract content, effluents) which are disposed of as waste (Fallows and Verner Wheelock 1982).

Blood is an inevitable by-product of the meat industry representing up to 4% of the live animal weight or 6% to 7% of the lean meat content of the carcass (Wisner-Pedersen 1988). Blood contains a number of compounds, which have potential commercial value and represents a valuable source of protein (Piot and others 1986). Tons of blood are collected in abattoirs each year, that is either processed into blood meal and sold as low-value animal food and fertilizer or discarded as effluent (Anderson and Yu 2003; Yu and others 2010). Animal blood produced in slaughterhouses represents a problematic by-product of the meat industry due to the high volumes generated and its very high pollutant load when discarded directly into the environment (Del Hoyo and others 2008).

The use of blood and its derivatives in various industries has been explored to some extent. For example, plasma proteins are

used as emulsifiers and whole blood is used in some traditional products such as black pudding. It is estimated that the food industry utilizes about 30% of the blood produced from slaughter (Gatnau and others 2001). However, issues surrounding the biological safety of blood collected from slaughtered animals (for example, the transmission of spongiform encephalopathies) have been raised (Hsieh and Ofori 2011). Religious constraints as well as negative consumer perception of blood for direct consumption have also contributed to its limited use in food applications. This has resulted in a search for alternative ways to use slaughterhouse blood, including the extraction of bioactive peptides.

Ockerman and Hansen (2000) suggested that human usage of animal blood may increase as worldwide protein deficiency increases and, therefore, sources of animal protein, such as blood, should be investigated now. The meat industry has been facing the task of better utilization of all slaughter products including blood (Gorbatov 1988). Finding new applications for blood components represents an important challenge for scientists (Silva and Silvestre 2003) and it is necessary to develop procedures and applications that will permit the utilization of animal blood on a larger scale, both to eliminate a sizable pollution hazard and prevent the loss of a potentially valuable material (Hyun and Shin 1998). As proteins constitute one of the main components of blood (Ockerman and Hansen 2000), the possibility of recovering proteins has been given considerable attention (Del Hoyo and others 2008). More recently, the recovery and extraction of bioactive compounds from blood, after suitable collection, has been seen as an opportunity to add economic value and generate new applications for slaughterhouse blood.

## General Physicochemical Characteristics of Blood

Blood is a red fluid, which is made up of water, cells, enzymes, proteins, and other organic and inorganic substances that can be separated into 2 fractions, the cellular fraction and plasma. The cellular fraction corresponds to 30% to 40% of blood wet weight and is dispersed within the liquid fraction, which is known as

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Table 1—Proteins from human blood and some properties.

Protein	Molecular weight (kDa)	Structure	pI
Albumin	66	Globular protein	~4.8
Fibrinogen	341	Glycoprotein consisting of 2 identical subunits. Each one is composed of 3 nonidentical polypeptide chains (A $\alpha$ , B $\beta$ , and $\gamma$ ), held together by 29 disulfide bonds.	~5.5
Immunoglobulin M	800 to 950	Polymers where multiple immunoglobulins are covalently linked together with disulfide bonds	
Immunoglobulin G	150	Symmetrical Y-shaped structure composed of 2 heavy chains and 2 light chains, held together by both disulfide bonds and noncovalent interactions	~7 to 9.5
Hemoglobin	68	Four separate polypeptides known as globins, of which $\alpha$ - and $\beta$ -chains are arranged in a spherical structure	~6.8
Prothrombin	72	Glycoprotein	~6.6
Transferrin	80	Iron binding monomeric glycoprotein	~6.3 to 6.4

Sources: Hsieh and Ofori (2011), Saguer and others (2012), Wismer-Pedersen (1988), Betgovegez and others (2005), Frost and others (2000), and Chung (1984).

Table 2—Blood constituents from commonly farmed animals.

Animal species	Content of blood (%)		Levels of protein constituents in whole blood (%)					
	Plasma	Cellular elements <sup>a</sup>	Albumin	$\alpha$ -globulins	$\beta$ -globulins	$\gamma$ -globulins	Fibrinogen	Hemoglobin
Cattle <sup>1</sup>	67.45	32.55	3.61	0.51	0.53	0.63	0.6	10.3
Pigs <sup>1</sup>	56.49	43.51	3.83	0.59	0.49	0.95	0.65	14.2
Sheep <sup>1</sup>	72.00	23.00	3.83	0.19	0.50	0.83	0.46	9.3
Deer <sup>2,3</sup>	50.50	49.50	3.80	0.29	0.47	0.70	N/A	10.2

<sup>1</sup>Gorbatov (1988), <sup>2</sup>White and Cook (1974), <sup>3</sup>Youatt (1965).

<sup>a</sup>Cellular elements represent red blood cells, white blood cells, platelets. N/A, data not available.

the plasma (which comprises up to 60%). The most important cellular elements are red corpuscles (erythrocytes), white corpuscles (leukocytes), and platelets. The granular white blood cells or leukocytes exist as 3 types based on their differently staining granules: neutrophil, eosinophil, and basophil. Hemoglobin is the major protein constituent of red blood cells, having a molecular weight as a tetramer of 68 kDa and consisting of 4 separate polypeptides known as globins, of which the  $\alpha$ - and  $\beta$ -chains are arranged in a spherical structure (Wismer-Pedersen 1988). An iron-containing heme group is located within each globin which can bind 1 molecule of oxygen, making a hemoglobin tetramer molecule capable of transporting 4 molecules of oxygen altogether.

Generally, 2 methods can be used to separate whole blood into fractions. These are either by centrifugation resulting in red cells and plasma or by allowing blood to clot in order to separate the red cells from the serum. Blood has a natural tendency to clot but the addition of an anticoagulant such as sodium citrate will prevent clotting. This happens when the citrate ions chelate calcium ions in the blood by forming calcium citrate complexes, thus disrupting the blood clotting mechanism. Other anticoagulants commonly used to prevent coagulation are heparin and ethylenediaminetetraacetic acid (EDTA).

Plasma, the part of the blood remaining after removal of the cells from unclotted blood, contains 6% to 8% proteins, consisting primarily of albumin, globulins, and fibrinogen. These, as well as more than 100 smaller proteins, have been well characterized. Some blood proteins and their molecular weights (based on human blood) are listed in Table 1.

Serum is qualitatively different from plasma in that the bulk of the fibrinogen has been removed by conversion into a fibrin clot together with the platelets which have either been physically bound in the fibrin matrix, or activated to form aggregates, or both. Varying amounts of other proteins are removed into the fibrin clot either by specific or nonspecific interactions (Lundblad 2005).

## Comparison of the Physicochemical Characteristics of Slaughterhouse Animal Blood

Blood is maintained relatively constant in composition due to the activity of the excretory systems and its composition of hormones, enzymes, and other biologically active substances. Some differences do exist among different animal species. For example, while the erythrocytes of the majority of farm animals such as sheep, cattle, and pigs are round, erythrocytes have an oval shape in deer and camel blood (Gorbatov 1988). The number of erythrocytes also varies with cattle and pigs having 6 to 8 million/mL<sup>3</sup>, sheep 6 to 11 million/mL<sup>3</sup>, and goats 14 to 18 million/mL<sup>3</sup>. Table 2 summarizes the main constituents of blood from different animal species.

The properties of erythrocytes (weight and coalescence) affect their precipitation and separation from the cellular elements. Blood from pigs separates comparatively quickly in contrast to cattle and sheep blood (Gorbatov 1988). The plasma content of animal blood also varies, with sheep blood reported to have the highest plasma content (Table 2). Globulins in plasma can be divided into alpha 1, alpha 2, beta, and gamma globulins. The most significant group of gamma globulins is the immunoglobulins (IgGs).

Species effects, geographical altitude, and maturity of the animal can contribute to the differences reported for blood hematological parameters. Looking at deer blood as an example, we can see that in different species of deer (fallow, red, Colorado mule), hemoglobin levels can range from 13.2 to 18.9 g/dL (Table 3). Free-ranging red deer had a lower number of red blood cells ( $8.8 \pm 0.9 \times 10^{12}/L$ ) and white blood cells ( $2.2 \pm 0.6 \times 10^9/L$ ) when compared to the other species of deer.

## Slaughterhouse Animal Blood Collection and Separation

Blood from slaughterhouse animals can be collected by 2 methods. The first, more primitive method, is open draining where blood from the animal is drained into buckets or trays. This method is more susceptible to contamination and blood collected this way

Table 3—Hematological parameters in different species of deer.

Parameter	Fallow deer ( <i>Dama dama</i> )	Red deer ( <i>Cervus elaphus</i> )	Colorado mule deer ( <i>Odocoileus hemionus</i> )
Packed cell volume (%)	47.1 ± 0.9 <sup>1</sup>	45.6 ± 2.81 <sup>1</sup> 35 ± 3.00 <sup>4</sup>	46.7 ± 0.6 <sup>2</sup>
Hemoglobin (g/dL)	17.2 ± 0.3 <sup>1</sup>	18.9 ± 0.97 <sup>1</sup> 13.16 ± 1.16 <sup>4</sup>	16.4 ± 0.3 <sup>2</sup>
Red blood cell (number × 10 <sup>6</sup> /μL)	9.91 ± 0.10 <sup>1</sup>	9.67 ± 0.51 <sup>1</sup> 8.8 ± 0.9 <sup>4</sup>	9.2 ± 0.2 <sup>2</sup>
Mean cell volume (f/L)	47.5 ± 0.63 <sup>1</sup>	47.0 ± 0.46 <sup>1</sup> 39.7 ± 4.1 <sup>4</sup>	52.8 ± 0.9 <sup>2</sup>
Mean cell hemoglobin	17.4 ± 0.2 <sup>1</sup>	19.6 ± 0.41 <sup>1</sup>	N/A
Mean cell hemoglobin concentration (g/dL)	36.6 ± 0.8 <sup>1</sup>	41.8 ± 1.12 <sup>1</sup> 38.13 ± 8.5 <sup>4</sup>	35.1 ± 0.2 <sup>2</sup>
Leukocytes (10 <sup>9</sup> /L)	N/A	4.8 ± 1.38 <sup>3</sup> 2.2 ± 0.6 <sup>4</sup>	3.0 ± 0.1 <sup>2</sup>
Neutrophil	N/A	40.07 ± 8.01 <sup>3</sup> 42.27 ± 22.27 <sup>4</sup>	40.6 ± 1.2 <sup>2</sup>
Band Neutrophil (%)	N/A	0.44 ± 1.15 <sup>3</sup>	1.1 ± 0.2 <sup>2</sup>
Lymphocyte (%)	N/A	48.13 ± 7.83 <sup>3</sup> 49.09 ± 13.64 <sup>4</sup>	43.4 ± 1.1 <sup>2</sup>
Monocyte (%)	N/A	5.13 ± 2.70 <sup>3</sup>	6.2 ± 0.45 <sup>2</sup>
Eosinophil (%)	N/A	2.94 ± 2.57 <sup>3</sup>	8.3 ± 0.61 <sup>2</sup>
Basophil (%)	N/A	3.12 ± 2.28 <sup>3</sup>	0.4 ± 0.07 <sup>2</sup>

<sup>1</sup>(Agar and Godwin 1992),<sup>2</sup>(Anderson and others 1970), <sup>3</sup>(Padilla and others 2000)—Red deer at high altitudes, <sup>4</sup>(Rosef and others 2010)—immobilized free ranging red deer. N/A, data not available.

is unlikely to be suitable for food applications. Blood, which is to be used for food applications has to come with a guarantee that it is sourced from veterinary-approved disease-free animals. In alive and healthy animals, blood is “sterile” (Dàvila Ribot 2007), in the sense that it can be consumed. However, contamination can occur during the blood collection process. Because of its high nutritional value, blood is particularly susceptible to bacterial growth.

The 2nd method is via a closed draining system, where blood from the slaughterhouse animal is not exposed to air and is drained directly from the body of the animal; for example, using a hollow knife connected to vacuum piping. However, this method can be more costly and slows down any slaughtering line speed (Dàvila Ribot 2007).

Recoverable blood could constitute up to 7% (carcass weight) of most animals (Wisner-Pedersen 1988). With the right collection procedures, this blood component can be used as raw material for products for human consumption as well as for technical products. Rigorous control of the temperature of the raw blood and plasma is necessary in order to ensure an end product that meets the exceptionally stringent requirements associated with food-quality ingredients. Many companies provide specialized equipment and systems for separating blood into high-grade plasma and hemoglobin, as well as specialized equipment for turning blood into feed protein products. Edible proteins must be processed with the utmost care if they are to be sold as a high-value item. Such processing must be configured to ensure gentle treatment that minimizes any shear effects that might rupture the red blood cells and contaminate plasma.

According to the FAOSTAT (2012) website, approximately 304 million cattle, 959 million sheep and goats, and 1374 million pigs were processed worldwide for their meat in 2010. Assuming a recovery of 15 L of blood from each head of cattle and 2 to 3 L per pig (Fallows and Verner Wheelock 1982), this would amount to huge volumes of blood (for example, cattle—4.56 billion L of blood), which represents a substantial resource and an interesting future opportunity for development. Blood from slaughterhouse animals is a better source when compared to donor animals in terms of volumes being generated. Utilizing slaughterhouse

blood in novel ways, such as the production of bioactive peptides (Figure 1), may help in reducing blood discharge and pollution of the environment.

### Animal Blood in Human Food Applications

Blood is a good source of nutrients suitable for human use. Anecdotal evidence of tribes drinking animal blood (for example, the Maasai in Africa) suggests the potential use of blood for sustenance. As mentioned previously, blood collected at abattoirs can be a valuable by-product if appropriately collected under hygienic conditions. The use of blood or blood components in food products to utilize the benefits from its nutritional value and functional properties is described in Table 4.

Several societies have utilized whole blood, as a source of protein, in products such as blood sausages, black puddings, or blood tofu. Several studies have also looked at using blood or its derivatives in other functional forms in food applications (Table 4). For example, Walter and others (1993) incorporated 6% bovine hemoglobin in cookies in a successful attempt to fortify the diets of schoolchildren with iron. The iron status of the children improved and the acceptability of the cookies was good (cookies had a chocolate flavor added to them and were indistinguishable from regular chocolate cookies).

Lee and others (1991) reported that nearly equivalent cake quality (firmness, cohesiveness, and color) was achieved by replacing egg whites with bovine plasma (in a 1 to 1.1 ratio). However, conflicting sensory results were reported, depending on the source of plasma protein and the method used to obtain it. For example, while Lee and others (1993) reported a 100% likeness for their plasma cakes, the majority of a sensory panel (64%) ascribed a strong objectionable flavor toward the cakes which had their egg whites replaced with bovine plasma in another study (Myhara and Kruger 1998).

Plasma proteins from pigs and chickens have also been tested for their use as protease inhibitors in the making of surimi, a form of fish gel (Visessanguan and others 2000). Also, a combination of porcine transglutaminase, fibrinogen, and thrombin has been used as a binder in restructured meat products (Tseng and others 2006).

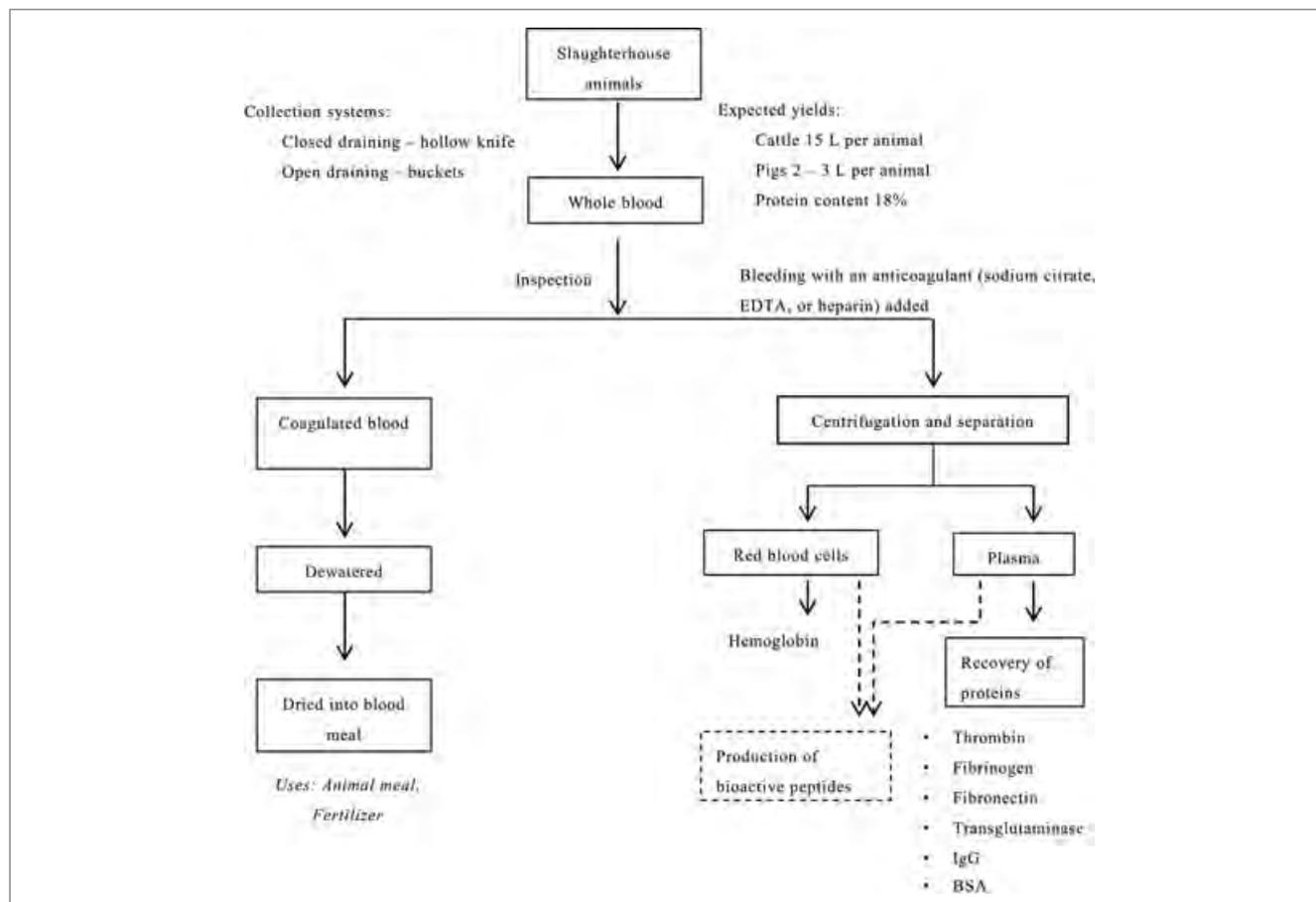


Figure 1—Animal blood collection and separation into usable fractions.

Table 4—Examples of animal blood use in food applications.

Blood fraction	Function	Food product	Reference
Whole animal blood	Protein source	Spanish blood sausage	Santos and others 2003
Bovine hemoglobin	Iron fortification	Cookies	Walter and others 1993
Bovine globin and plasma	Fat replacer	Ham pâté	Viana and others 2005
Animal plasma	Fat replacer	Bologna (fermented) sausage	Cofrades and others 2000
Porcine transglutaminase, fibrinogen, thrombin	Binder	Restructured meat products	Tseng and others 2006
Porcine plasma	Protease inhibitor	Surimi	Visessanguan and others 2000
Chicken plasma	Protease inhibitor	Surimi	Rawdkuen and others 2004
Bovine plasma	Egg white replacer	Cakes	Lee and others 1991
Processed bovine plasma	Emulsifier, Stabilizer	Minced meats	Myhara and Kruger 1998 Furlán and others 2010

Several companies have commercialized food-grade proteins from animal blood. ImmunoLin<sup>®</sup>, produced by Proliant Inc., Boone, Iowa U.S.A., is a serum concentrate from bovine plasma advertised as containing immunoglobulins, transferrin, mitogenic growth factors, and immune-regulating cytokine, which can be added to bars and drinks with the intention to boost the immune system. Fibrimex<sup>®</sup> is a combination of thrombin and fibrinogen concentrate precipitated from bovine plasma, manufactured by Sonac B.V, The Netherlands. The product can be used for the bonding of muscle tissue. Some controversy has arisen recently over the use of binding agents such as this, which have been labeled as “meat glue.” Sonac (a part of Vion Ingredients in The Netherlands) also produces Harimix P, P+, and C proteins, which are hemoglobin powders derived from bovine, porcine, and hemoglobin liquid from bovine and porcine blood. These products can be used as a natural meat colorant. Licán, a company

operating in Brazil, Chile, and Paraguay, produces Prolican 70 (spray-dried bovine plasma) for emulsifying, gelling, and binding, Prietin (spray-dried porcine whole blood) for blood sausages, and Myored (red pigments from blood) for use as a natural colorant. Similarly, the Veos Group in Belgium markets a range of products under the Vepro<sup>®</sup> brand utilizing plasma and hemoglobin from animal blood for various food applications.

### Animal Blood in Other Applications

Apart from the food applications mentioned above, animal blood has also been used in other industrial applications (Table 5). For example, whole blood from cow, sheep, pig, or chicken has been added to pet food as a cheap protein source, while, on the other side of the scale, compounds with higher value medical applications such as thrombin (EC 3.4.21.5) and plasmin have been recovered from animal blood.

Table 5—A summary of medical and industrial applications of animal blood.

Blood source	Sector	Function/use	Reference
Cow, sheep, pig, or chicken whole blood	Pet food	Protein source	Patent US4089978
Spray-dried bovine and porcine plasma	Animal feed	Enhancement of growth rate and feed intake	Pierce and others 2005
Porcine plasma	Animal feed	Protein source for weaned piglets	Proglobulin® produced by Sonac (Vion Ingredients Group)
Hemoglobin	Aquatic feed	Food source for carnivorous fish or shrimp	Hemoglobin in aqua feed produced by Sonac (Vion Ingredients Group)
Hemoglobin	Pet food	Cattle, poultry, piglet, fish, and pet food	Actipro® produced by the Veos Group
Plasma	Animal feed		
Globin			
Bovine plasma albumin	Laboratory	Immunoematology	Tanaka and others 2001
		Testing for Rh factor in humans	Jayathilakan and others 2011
Porcine plasmin enzyme	Medical	To digest fibrin in blood clots in heart attack patients	Jayathilakan and others 2011
Bovine thrombin	Medical	Promotes blood coagulation	Jayathilakan and others 2011
		Treatment of wounds	
		Hold skin grafts in place	
Bovine plasma	Microbiology	Medium for the growth of probiotic bacteria ( <i>Lactobacillus</i> sp.)	Hyun and Shin 1998
Bovine plasma powder	Feed supplement	For nonruminant animals	Bovogen Biologicals Pty Ltd (Australia)
Bovine hemoglobin powder	Pharmaceutical	Use as a raw material for pharmaceutical porphyrin derivative production.	Bovogen Biologicals Pty Ltd (Australia)
Bovine fibrinogen	Microbiology	Reagent in Baird Parker microbiological media for <i>Staphylococcus aureus</i> identification	Bovogen Biologicals Pty Ltd (Australia)
	Medical	Reagent for routine blood clotting in serology laboratories	
		Bioengineering scaffolding applications	
Bovine prothrombin	Medical	Use as a precursor to thrombin production and purification	Bovogen Biologicals Pty Ltd (Australia)
		Active ingredient in topical surgical hemostatic applications	
Abattoir derived: Defibrinated, lysed, laked blood	Research		Lampire Biological Laboratories (USA)
Whole blood			
Red blood cells from bovine, calves, porcine animals			

Pierce and others (2005) conducted experiments to evaluate the effects of dietary spray-dried porcine plasma (SDPP) and spray-dried bovine plasma (SDBP) and their various fractions on the performance of pigs weaned at approximately 14 or 21 d of age. In addition, the efficacy of various levels of the immunoglobulin G (IgG)-rich fraction of SDPP and SDBP were evaluated. The results indicated that both porcine and bovine plasma were beneficial to young pig performance during the 1st week after weaning and that the IgG fraction of plasma was the component responsible for the enhancement in growth rate and feed intake.

### Bioactive Peptides from Food By-products

For the purpose of this review, bioactive food compounds are defined as naturally occurring nonessential constituents in or derived from plant, animal, or marine sources, which have the ability to modulate biochemical, physiological, and metabolic processes in the human body while exerting beneficial effects beyond basic nutritional functions (Kris-Etherton and others 2004).

Bioactive compounds include a large array of compounds such as peptides, oligosaccharides, fatty acids, enzymes, water-soluble minerals, and biopolymers. These compounds can be present naturally in food sources or be produced *in vivo* (gastrointestinal digestion), by industrial enzymatic digestion (food processing activities)

or by microbial fermentation (Hernández-Ledesma and others 2011).

Bioactive peptides are short sequences of approximately 2 to 20 amino acids in length that exert physiological benefits. Their bioactivities depend on their amino acid composition and sequence. These peptides can be “encrypted” or inactive within the sequence of the parent proteins and may be released by proteolytic hydrolysis using commercially available enzymes, proteolytic microorganisms, or fermentation methods (Davies and others 2005; Vercruyse and others 2005). After digestion, bioactive peptides can be absorbed from the intestine and enter the blood stream directly, which facilitates their bioavailability *in vivo* enabling a physiological effect at the target site (Erdmann and others 2008).

A wide range of activities from bioactive peptides derived from food sources has been described, including antimicrobial properties, blood pressure-lowering (ACE-inhibitory) effects, cholesterol-lowering ability, antithrombotic and antioxidant activities, enhancement of mineral absorption/bioavailability, cyto- or immunomodulatory effects, and opioid activities. Some peptides can be multifunctional and are able to exert more than one effect (Lantz and others 1991; Korhonen and Pihlanto 2003).

Through the control and improvement of physiological functions, bioactive peptides have the potential to provide new

therapeutic applications for the prevention or treatment of chronic diseases. Thus, by adding bioactive peptides as components of functional foods or nutraceuticals, bioactive peptides may improve commercial returns (McConnell and others 2001; Erdmann and others 2008). The use of multifunctional peptides from natural sources for therapeutic purposes (for example, those that have anti-inflammatory and antimicrobial activities) may have wider economic benefits, as they would be more appealing to consumers.

Some researchers have highlighted that the ability of bioactive peptides to exert a physiological effect *in vivo* is dependent on the bioavailability of the peptide. This factor is dependent on the resistance of the bioactive peptide to hydrolysis by peptidases present in both the intestinal tract and blood stream serum, and the ability of the peptides generated to be absorbed across barriers such as the intestinal epithelium. Consequently, in the course of identifying bioactive peptides for the development of food-based nutraceutical products, this fact should be taken into account (Ryan and others 2011). Foltz and others (2010) caution that the stimulatory or inhibitory effects on target proteins *in vitro* has often been used as the justification to test these compounds directly *in vivo*. Unfortunately, this research approach has an inherent flaw as the *in vitro* method tends to neglect the poor absorption, distribution, metabolism, and excretion (ADME) properties of peptides, which may result in low peptide bioavailability. Because peptides usually undergo extensive hydrolysis in the gastrointestinal tract by peptidases present in the stomach, most of them do not actually arrive or reach the absorption stage in the duodenum and jejunum. Therefore, a valid research approach should consider including the demonstration of peptide stability and evaluate its ADME properties before further establishing bioactivity *in vivo* (Foltz and others 2010).

### Bioactives Isolated from Animal Blood

An emerging new area, focused on obtaining bioactive peptides from blood fractions, has been developing intensively over the past decade (Wanasundara and others 2002b; Nedjar-Arroume and others 2008; Wei and Chiang 2009; Parés and others 2011; Toldrá and others 2012). Results from several studies, using predominantly bovine and porcine blood, have indicated that bioactive peptides from blood sources have angiotensin I-converting enzyme (ACE)-inhibitory activity, antioxidant activity, antimicrobial properties, mineral-binding ability, and opioid activity. These will be described in detail in the following sections.

#### Angiotensin I-converting enzyme inhibitory peptides

Angiotensin I-converting enzyme (ACE) is a dipeptidyl carboxypeptidase (EC 3.4.15.1) that converts an inactive form of the decapeptide, angiotensin I, to a potent vasoconstrictor, octapeptide angiotensin II (Li and others 2004). ACE also inactivates bradykinin, which has a depressor or vasodilatational (widening of blood vessels) action. Through these actions, ACE elevates blood pressure (Figure 2). Therefore, by inhibiting the catalytic action of ACE, the elevation of blood pressure can be suppressed (Arihara and Ohata 2008) and an overall antihypertensive effect can be achieved (Shalaby and others 2006).

Various ACE-inhibitory drugs such as captopril, enalapril, alacepril, and lisinopril have been used in the treatment of high blood pressure. However, these synthetic inhibitors have certain side effects, such as cough, taste disturbances, and skin rashes. Serious side effects, such as proteinuria and blood dyscrasias, have been reported, especially when captopril is given in high dosage or to patients with renal failure (The Lancet Editorial 1980). Several

peptides derived from food proteins (for example from milk, meat, seafood, and plant hydrolysates) have been shown to exert ACE-inhibitory activity and are considered to be milder and safer than synthetic drugs (Yu and others 2006). Furthermore, the activities reported for natural peptides with ACE-inhibitory activity usually have other bioactivities (multifunctional properties) and are easily absorbed (Lantz and others 1991; Korhonen and Pihlanto 2003; Yu and others 2006; Adje and others 2011b).

**Effect of enzymes on the generation of hydrolysates with ACE-inhibitory activity.** Although the activities of bioactive peptides in the sequences of the parent proteins are latent, they can be released by proteolytic enzymes. In this aspect, meat (and also blood) proteins have possible bioactivities beyond a nutritional source of amino acids alone (Arihara and Ohata 2008).

Proteolytic enzymes hydrolyze the peptide linkage between amino acids of proteins, yielding a mixture of peptides of different molecular size and free amino acids. As the ability of peptidases to hydrolyze proteins is highly variable, the selection of suitable enzymes for production of hydrolysates having defined physicochemical and nutritional characteristics is essential (Clemente 2000).

The choice of substrate and protease employed and the degree to which the protein is hydrolyzed can greatly affect the physicochemical properties of the resulting hydrolysates. Enzyme substrate specificity is also important to hydrolysate functionality because it strongly influences its molecular size and the hydrophobic/hydrophilic balance; the broader the protease specificity, generally the smaller are the peptides produced and the more complex the peptide profile becomes. For the economic production of bioactive peptides, high productivity in peptide production and a good availability of protein source and proteolytic enzyme is required. High productivity will be achieved by producing more active peptide fractions at higher yields (Hyun and Shin 2000).

Researchers have used a number of proteases to hydrolyze animal blood in the initial stages of attempting to obtain peptides with ACE-inhibitory activity. Alcalase (EC 3.4.21.62), Neutrase, pepsin (EC 3.4.23.1), papain (EC 3.4.22.2), trypsin (EC 3.4.21.4), and Flavourzyme have been utilized to determine which enzyme is best able to generate crude hydrolysates with the highest ACE inhibitory activities (Table 6).

Alcalase (an endoprotease from *Bacillus licheniformis*) was chosen by several researchers as it has a low cost and high yield. For example, Alcalase was selected for the enzymatic digestion of bovine plasma proteins because it exhibited the highest proteolytic activity compared to trypsin, neutrase, pepsin, and papain (Hyun and Shin 2000). Neutrase, a metalloprotease containing *Bacillus subtilis* neutral proteases, was not able to hydrolyze the bovine whole plasma proteins efficiently. The protease pepsin, which is of animal origin, was able to hydrolyze the plasma proteins moderately, but papain (which is from the papaya—of plant origin) had a low degree of hydrolysis. Bovine plasma was not able to be hydrolyzed by trypsin. The authors believed that this was due to the presence of several trypsin inhibitors in whole bovine plasma (Hyun and Shin 2000). However, trypsin was able to hydrolyze isolated bovine albumin at a higher level, in comparison to isolated bovine globulin.

It has been documented that Alcalase is limited by its hydrolysis specificity and depending on the substrate; the highest degree of hydrolysis (DH) that can be reached is 20% to 25% (Adler-Nissen 1986; Pommer 1995). Wanasundara and others (2002a) preferred Flavourzyme to Alcalase. When the 2 enzymes were compared for their ability to hydrolyze defibrinated bovine plasma (DBP)

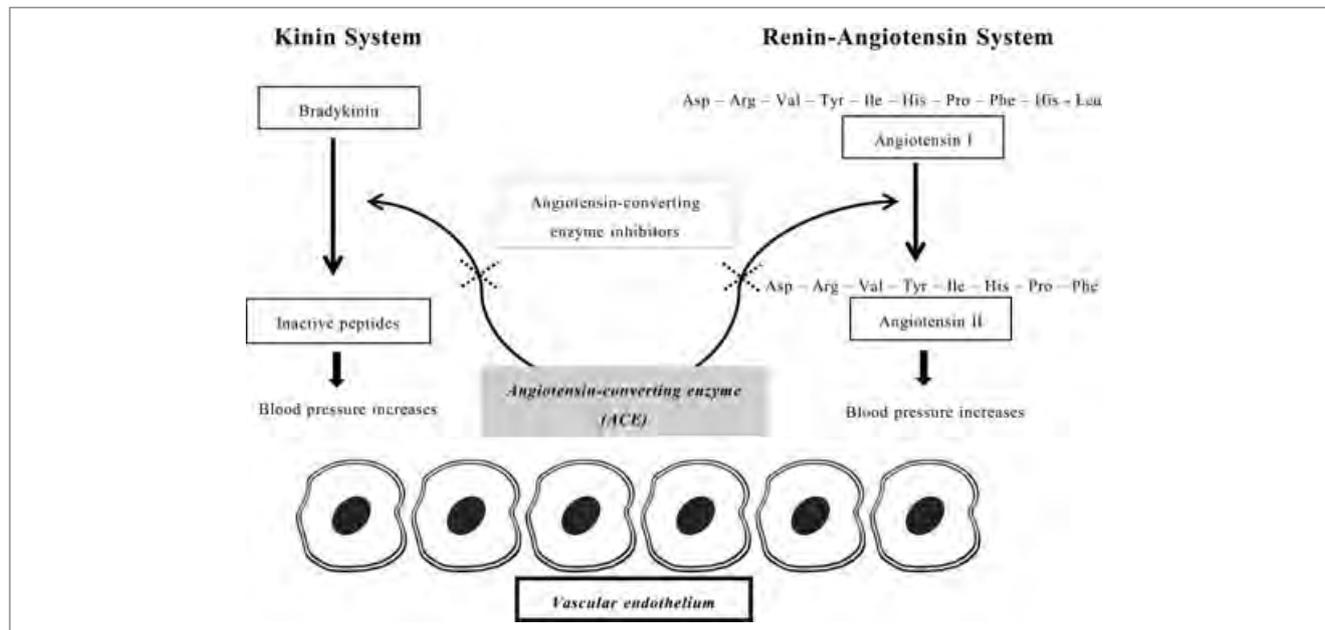


Figure 2–Blood pressure regulation by angiotensin I-converting enzyme (ACE).

Table 6–Enzymes used to generate animal blood-derived hydrolysates with ACE- inhibitory activity.

Protein source (substrate)	Substrate concentration	Protease	Enzyme-to-substrate ratio	Temperature	pH	Reference
Bovine hemoglobin	N/A	Pepsin	1% (w/v)	23 °C	5.5	Adje and others 2011b
Bovine whole plasma	0.09 g/mL in 50 mM PBS (pH 7.4) Protein concentration was then adjusted to 40 mg protein/mL with distilled water	Alcalase Neutrase Pepsin Papain Trypsin	0.05% (w/w) 1.0% (w/w) 0.25% (w/w) 2.0% (w/w)	55 °C 45 °C 37 °C 25 °C	7.5 6.2 2.0 6.2	Hyun and Shin 2000
Bovine albumin	0.09 g/mL in 50 mM PBS (pH 7.4) Protein concentration was then adjusted to 40 mg protein/mL with distilled water	Alcalase Trypsin	0.0005% (w/w) 0.0025% (w/w)	55 °C 37 °C	7.5 7.5	Hyun and Shin 2000
Bovine globulins	0.09 g/mL in 50 mM PBS (pH 7.4) Protein concentration was then adjusted to 40 mg protein/mL with distilled water	Alcalase Trypsin	0.01% (w/w) 1.0% (w/w)	55 °C 37 °C	7.5 7.5	Hyun and Shin 2000
Defibrinated bovine plasma	N/A	Flavourzyme	110 LAPU/g protein	50 °C	7.0	Wanasundara and others 2002b
Porcine hemoglobin	N/A	Alcalase	124g / 20kg	50 °C	9.0	Mito and others 1996
Porcine red blood cell corpuscles	10 g/L in 0.1 mol/L PBS (pH 7.4)	Alcalase Alcalase + Flavourzyme	1:50	55 °C 55 °C	7.5 7	Wei and Chiang 2009
Plasma		Trypsin		38 °C	7	
Defibrinated plasma		Trypsin + Chymotrypsin + Thermolysin		35 °C	7.5	
Porcine globin	30 mg/mL in 0.067 M PBS buffer	Pepsin Trypsin Papain	1% (w/w) 1% (w/w) 1% (w/w)	37 °C 37 °C 37 °C	2.0 7.5 7.5	Yu and others 2006
Porcine globin	18%	Pepsin	8% pepsin	35 °C followed by 55 °C followed by	3	Ren and others 2011
Cervine plasma	N/A	Trypsin	3:1 (w/w) 1:100 (w/w)	37 °C 37 °C	8.0	Liu and others 2010b

LAPU, leucine amino peptidase units; N/A, information not available.

proteins, Alcalase gave a maximum of  $24.8 \pm 1.5$  DH% at the highest enzyme concentration (0.5 AU/g protein) and prolonged hydrolysis (24 h) while Flavourzyme was more efficient in hydrolyzing DBP and gave  $48.3 \pm 2.3$  DH% at 24 h of hydrolysis when 100 LAPU/g protein was used. Flavourzyme is a fungal

protease complex produced by *Aspergillus oryzae* containing endo- and exopeptidases which give it broader specificity; thus, high DH values can be achieved. An endo- and exopeptidase complex can hydrolyze the peptide bonds in a protein molecule more completely than an endopeptidase such as Alcalase (Chang and

others 2007). Bovine plasma proteins in their native state were not susceptible to hydrolysis by Alcalase or Flavourzyme but pretreatment heat denaturation (for example 90 °C for 20 min) prior to hydrolysis was found to be effective in improving hydrolysis values. The heat-denaturation of plasma proteins causes the molecules to unfold and makes them more accessible to proteases for hydrolytic reaction than in their native state (Wanasundara and others 2002a).

Yu and others (2006) performed the hydrolysis of globin obtained from porcine hemoglobin individually with 3 proteases at the same temperature (37 °C): pepsin (at pH 2.0), trypsin (pH 7.5), and papain (pH 7.5). The highest ACE-inhibitory activity was found using the pepsin hydrolysate (IC<sub>50</sub> of 1.19 mg/mL) while trypsin, which cleaves peptide bonds that are C-terminal to Arg and Lys, had the lowest ACE-inhibitory activity of the 3 proteases used. Liu and others (2010b) were able to use trypsin for the hydrolysis of cervine plasma (pH 8.0, 37 °C). Pepsin was used by Ren and others (2011) for porcine globin hydrolysis (pH 3, 35 to 55 °C) and also by Adje and others (2011b) as the enzyme of choice for the hydrolysis of bovine hemoglobin at pH 5.5, 23 °C, in the presence of 30% ethanol which, according to the authors, would result in structured, hydrophobic, and positively charged peptides.

The enzyme-to-substrate (E/S) ratio could also be an important factor in obtaining hydrolysates with higher ACE-inhibitory activity. The ACE-inhibitory activity of porcine blood hydrolysates increased as the E/S ratio increased. An E/S ratio of 1:5 produced hydrolysates with the highest ACE-inhibitory activity when compared to hydrolysates from E/S ratios of 1:10 and 1:100 (Wei and Chiang 2009).

**Effect of the Degree of Hydrolysis on the Generation of Hydrolysates with ACE-Inhibitory Activity.** The degree of hydrolysis is a measure of the extent of hydrolytic degradation of proteins. It is the most used indicator for comparison among different proteolytic processes, although different methods such as pH-stat, osmometry, soluble nitrogen content, trinitrobenzene-sulfonic acid (TNBS), and o-phthalaldehyde (OPA) can be used to monitor the degree of hydrolysis (Nielsen and others 2001).

Different degrees of hydrolysis were obtained depending on the enzyme-to-substrate ratio and hydrolysis time employed when Flavourzyme was used to hydrolyze defibrinated bovine plasma. A 43% DH with the highest inhibiting ACE activity (78.93% or IC<sub>50</sub> of 1.08 mg/mL) was achieved using an enzyme concentration of 110 leucine amino peptidase units/g protein and 15.5 h of hydrolysis time (Table 7). Unhydrolyzed defibrinated bovine plasma had a negligible amount of ACE-inhibitory activity (Wanasundara and others 2002b).

A hydrolysate of bovine albumin using Alcalase generated the most active ACE-inhibitory activity (IC<sub>50</sub> of 0.56 mg/mL) at a hydrolysis time of 4 h using 0.5% (w/w) enzyme (Hyun and Shin 2000) with a peptide yield of 69.2%. The major plasma proteins were degraded due to hydrolysis; peptides of less than 1.04 kDa were dominant in the product when a high degree of hydrolysis was employed (Wanasundara and others 2002a).

Thus, the results from the above research demonstrate the importance and potential of obtaining an active ACE inhibitor from crude hydrolysates of blood by optimizing the hydrolysis processing conditions.

**Effect of peptides on ACE-inhibitory activity.** In bovine hemoglobin, peptides  $\alpha$  99 to 105 and  $\alpha$  100 to 105 both demonstrated ACE-inhibitory activity (Table 8). These 2 peptides are different by only 1 amino acid at the N-terminal

end (Adje and others 2011b). However, the ACE-inhibitory activity of  $\alpha$  99 to 105 was much stronger than that of  $\alpha$  100 to 105. One possible explanation for this lies in the presence of a lysine residue at position 99, which contributes to an increase in the peptide's hydrophobicity, an important characteristic that contributes to ACE-inhibitory activity (Adje and others 2011b). ACE prefers to have substrates or competitive inhibitors that contain hydrophobic amino acid residues such as proline, phenylalanine, and tyrosine at 3 positions from the C-terminal end (Cheung and others 1980). The relationships between the structure and activity level of various ACE-inhibitory peptides indicate that binding to ACE is strongly influenced by the C-terminal tripeptide sequence of the substrate. A study on the peptic hydrolysis of bovine hemoglobin proposed that a short reaction time (about 20 min) would yield hydrolysates with a more hydrophobic nature, whereas an extensive reaction (about 16 h) was suggested to prepare hydrolysates with a more hydrophilic nature (Su and others 2006).

The lowest ACE-inhibitory activity was reported from a bovine albumin-derived peptide with a size of <1000 Da. ACE-inhibitory activity increased with decreasing MW cut-off and total peptides when bovine albumin hydrolysates were further processed and purified. This indicates that the molecular weights of active peptides are usually lower than 1000 Da (Hyun and Shin 2000). The ACE-inhibitory peptides identified in the study by Wanasundara and others (2002b) are very short and presumed to have originated from serum albumin and globulins, as this particular plasma protein product (defibrinated bovine plasma) is devoid of thrombin and fibrinogen.

There was little change in the ACE-inhibitory activity of the peptides after *in vitro* incubation with gastrointestinal proteases (pepsin, chymotrypsin, and trypsin), suggesting that these peptides might then be resistant to digestion in the gastrointestinal tract. Yu and others (2006) tested the stability of their 2 purified peptides obtained from the hydrolysis of porcine globin using pepsin. Shorter peptides are less likely to be cleaved by gastric proteases (Wanasundara and others 2002b). This is interesting as the antihypertensive effect of ACE inhibitory peptides is strongly influenced by their bioavailability, which is predominantly determined by the resistance to peptidase degradation and intestinal absorption.

**Antioxidant peptides from animal blood sources.** Methods for assessing antioxidant activity of a compound fall into 2 broad categories reflecting the focus on activity in foods or bioactivity in humans (Antolovich and others 2002), while antioxidant assays can be divided into *in vitro* and *in vivo* types. The antioxidant activity of protein hydrolysates or peptides is usually tested by *in vitro* assays (Di Bernardini and others 2011). On the basis of the chemical reactions involved, major antioxidant capacity assays can be roughly divided into 2 categories: (1) hydrogen atom transfer (HAT) reaction-based assays and (2) single electron transfer (ET) reaction-based assays (Huang and others 2005). There is no standardized method to study the antioxidant activity of a substance, and for this reason it is recommended to study the antioxidant activity with various oxidation conditions and different antioxidant methods (Frankel and Meyer 2000; Antolovich and others 2002; Sanchez-Moreno 2002). Antolovich and others (2002) also caution that the term "activity" as applied to antioxidants needs clarification as it can have a variety of meanings, and relevant aspects include: mechanistic intervention, for example, free radical scavenger, catalytic decomposition, and pro-oxidant suppression; rate of scavenging, for example, near-diffusion or controlled;

Table 7—Degree of hydrolysis and ACE inhibitory activity of blood-derived hydrolysates.

Protein source	Protease	Hydrolysis time (h)	Peptide yield/degree of hydrolysis (%)	ACE-inhibitory activity	Reference
Bovine hemoglobin	Pepsin		1%	N/A	Adje and others 2011b
Bovine whole plasma	Alcalase	2	58.0 <sup>a</sup>	2.53 <sup>b</sup>	Hyun and Shin 2000
	Neutrase	1	16.5 <sup>a</sup>	10.50 <sup>b</sup>	
	Pepsin	4	37.6 <sup>a</sup>	17.19 <sup>b</sup>	
	Papain	2	10.1 <sup>a</sup>	23.47 <sup>b</sup>	
	Trypsin	—	0.2 <sup>a</sup>	—	
Bovine albumin	Alcalase	4	69.2 <sup>a</sup>	0.56 <sup>b</sup>	Hyun and Shin 2000
	Trypsin	2	58.3 <sup>a</sup>	0.89 <sup>b</sup>	
Bovine globulins	Alcalase	4	32.4 <sup>a</sup>	7.11 <sup>b</sup>	Hyun and Shin 2000
	Trypsin	8	16.2 <sup>a</sup>	8.14 <sup>b</sup>	
Defibrinated bovine plasma	Flavourzyme	—	Unhydrolyzed	3.20 ± 1.45 <sup>c</sup>	Wanasundara and others 2002b
		N/A	13	61.50 ± 1.57 <sup>c</sup>	
		N/A	26	73.07 ± 1.86 <sup>c</sup>	
		N/A	38	75.72 ± 0.82 <sup>c</sup>	
		15.5	43	78.93 ± 2.04 <sup>c</sup>	
Porcine hemoglobin	Alcalase	2	15	N/A	Mito and others 1996
Porcine globin	Pepsin	12	N/A	1.19 <sup>b</sup>	Yu and others 2006
	Trypsin	12	N/A	8.79 <sup>b</sup>	
	Papain	12	N/A	2.21 <sup>b</sup>	
Porcine red blood corpuscles	Trypsin	10		2.80 <sup>b</sup>	Wei and Chiang 2009
	Trypsin + Chymotrypsin + Thermolysin	6		0.58 <sup>b</sup>	
	Alcalase	2		1.60 <sup>b</sup>	
	Alcalase + Flavourzyme	10		1.24 <sup>b</sup>	
Porcine plasma	Trypsin	10		4.10 <sup>b</sup>	Wei and Chiang 2009
	Trypsin + Chymotrypsin + Thermolysin	2		0.80 <sup>b</sup>	
	Alcalase	6		1.24 <sup>b</sup>	
	Alcalase + Flavourzyme	2		1.37 <sup>b</sup>	
Porcine defibrinated blood plasma	Trypsin	ND		ND	Wei and Chiang 2009
	Trypsin + Chymotrypsin + Thermolysin	2		1.06 <sup>b</sup>	
	Alcalase	24		2.20 <sup>b</sup>	
	Alcalase + Flavourzyme	ND		ND	
Porcine globin	Pepsin	7	N/A	4.37 <sup>b</sup>	Ren and others 2011

<sup>a</sup> Peptide yield from proteolytic reaction with 0.5% (w/w) protease.

<sup>b</sup> IC<sub>50</sub> (mg/mL).

<sup>c</sup> % ACE inhibitory activity.

N/A, data not available; ND, not detectable.

medium or substrate selectivity (for example, aqueous, surface, or lipid phase); concentration effectiveness (moles of free radicals scavenged per mole of antioxidant); and synergistic effect for other antioxidants.

**Effect of enzymes on the antioxidant activity of hydrolysates from animal blood sources.** Different enzymes were utilized by researchers to generate hydrolysates with antioxidant activity (Table 9) in a similar fashion to that previously described for ACE-inhibitory peptides. To hydrolyze porcine hemoglobin, Chang and others (2007) used Alcalase and a combination of Alcalase followed by Flavourzyme, while Sun and others (2011c) used Flavourzyme, papain, A.S. 1398, Alcalase, pepsin, and trypsin to screen for hydrolysates with the highest antioxidant activity. For porcine plasma, Wang and others (2008) and Liu and others (2010a) used Alcalase as their protease of choice for hydrolysis, although at different enzyme-to-substrate ratios. Xu and others (2009) meanwhile used pepsin and papain in their hydrolysis of porcine plasma. The hydrolysis temperature for Alcalase was 50 to 55 °C, for Flavourzyme 40 to 45 °C, papain and pepsin 37 °C, and trypsin and A.S. 1398 45 °C. Optimal pH range or values reportedly used by researchers for each enzyme were pH 7.5 to 8.0 for Alcalase, pH 6.5 to 7.5 for Flavourzyme, pH 6.5 to 8.0 for papain, pH 2.0 for pepsin, pH 7.0 for A.S. 1398, and pH 7.5 for trypsin.

The effects of pepsin-assisted hydrolysis conditions on the antioxidant activity of porcine hemoglobin hydrolysate were investi-

gated and the effects of temperature, pH, and enzyme-to-substrate ratio on the antioxidant activity were evaluated and compared using response surface methodology (Sun and others 2011a). Temperature and pH were found to be the major factors affecting the antioxidant activity of porcine hemoglobin hydrolysates, while enzyme-to-substrate ratio influenced antioxidant activity to a lesser extent. Properties of hydrolysates are largely dependent on the primary structure of the peptide residuals as a consequence of the type of hydrolyzing enzymes, coupled with hydrolysis conditions, degree of hydrolysis and substrate pretreatment. Therefore, a careful choice of process parameters is of utmost importance for successful hydrolysis.

**Effect of the degree of hydrolysis on the antioxidant activity of hydrolysates from animal blood sources.** Although Alcalase hydrolysis of porcine hemoglobin produced a higher degree of hydrolysis (about 17%) in comparison to pepsin (DH 7.7%), the DPPH scavenging activity of hydrolysates using pepsin was higher (67% compared to 27%) (Sun and others 2011c). The authors reported that there was no correlation between extent of hydrolysis and antioxidant activity ( $P > 0.05$ ) and suggested that since pepsin preferably digests peptide bonds by cleaving after the N-terminal of aromatic amino acids, such as phenylalanine (F), tryptophan (W), and tyrosine (Y), the phenyl groups of the residues at peptide ends were likely to be scavenging the free radical to prevent DNA damage. This result indicates that the antioxidant activity of the

Table 8—Peptides with ACE inhibitory activity from blood-derived sources.

Source	Peptide size (Da)	Amino acid sequence	Level of activity (IC <sub>50</sub> )	Reference			
Bovine albumin	<1000	N/A	0.09 mg/mL	Hyun and Shin 2000			
Defibrinated bovine plasma	156	H	The fraction which contained all the peptides listed to the left had an ACE-inhibitory activity of 63.18 ± 2.73%	Wanasundara and others 2002b			
	269	H-(L or I)					
	279	(L or I)-F (*LF is conserved within bovine serum albumin)					
	336	GYP					
	416	HPY (conserved within bovine serum albumin)					
	366	SPY					
	416	YPH					
	428	HPGH					
	Bovine hemoglobin	4430.1			α 67 to 106 TKAVEHLDDLPGALSESDLH AHKLRVDPVNFKLLSHSL	366 ± 16.10 μM	Adje and others 2011b
		3651.1			α 73 to 105 LDDLPGALSESDLHAHKLR VDPVNFKLLSHSL	518.29 ± 37.3 μM	
797		α 99 to 105 KLLSHSL	42.51 ± 3.96 μM				
669		α 100 to 105 LLSHSL	1095.5 ± 65.5 μM				
1555		α 34 to 46 LGFPTTKTYFPHF	4.92 μM				
Porcine hemoglobin	N/A	β 34 to 39 VVYPWT	6.02 μM	Yu and others 2006			
	N/A	β 130 to 136 FQKVVA	5.8 μM				
Porcine hemoglobin	N/A	β 130 to 137 FQKVVAG	7.4 μM	Mito and others 1996			
	N/A	FQKVVAK	2.1 μM				
	N/A	β 64 to 69 GKKVLQ	1.9 μM				
	N/A	WVPSV	0.368 mg/mL				
Porcine hemoglobin	N/A	YTVF	0.226 mg/mL	Ren and others 2011			
	N/A	VVYPW	0.254 mg/mL				
	N/A	GVHVV	6 μM				
Porcine plasma	N/A	LVL	0.6 μg/mL	Park and others 1996			
Porcine plasma	N/A	VYNEGLPAP	3.1 μM	Hazato and Kase 1986			
Cervine plasma	N/A			Liu and others 2010b			

N/A, data not available.

Table 9—Enzymes used to generate crude hydrolysates from animal blood sources with antioxidant activity.

Protein source (substrate)	Substrate concentration	Enzyme	Enzyme-to-substrate ratio	Temperature	pH	Reference
Porcine hemoglobin	0.05 g/mL dried hemoglobin in 0.1 N NaOH	Alcalase	2%	50 °C	pH 8.0	Chang and others 2007
		Flavourzyme	1%	40 °C	pH 7.5	
		Alcalase followed by Flavourzyme	2%	50 °C	pH 7.5	
Porcine hemoglobin	1 mg/mL	Pepsin	1.6% (w/w)	40.4 °C	pH 1.6	Sun and others 2011a
Porcine hemoglobin	0.05 g/mL dried hemoglobin in distilled water	Flavourzyme	0.5% (w/w)	45 °C	pH 6.5	Sun and others 2011c
		Papain	0.3% (w/w)	37 °C	pH 6.5	
		A.S. 1398	0.2% (w/w)	45 °C	pH 7.0	
		Alcalase	0.2% (w/w)	55 °C	pH 8.0	
		Pepsin	1.6% (w/w)	37 °C	pH 2.0	
		Trypsin	0.2% (w/w)	45 °C	pH 7.5	
Porcine plasma albumin and globulin	0.08 g/mL of each powder in 50 mM PBS (pH 7.5)	Alcalase	0.1% (w/w)	55 °C	pH 7.5	Wang and others 2008
Porcine plasma	40 mg protein/mL	Alcalase	2:100 (w/w)	55 °C	pH 8.0	Liu and others 2010a
Porcine plasma	0.2 g/L in distilled water	Pepsin	25:1 (w/w)	37 °C	pH 2.0	Xu and others 2009
		Papain	20:1 (w/w)	37 °C	pH 8.0	

hydrolysates is inherent to the characteristic amino acid sequences of peptides depending on protease specificities.

The DH of porcine albumin and globulin hydrolysates using Alcalase increased with increasing hydrolysis time and reached the highest values at 24 h of hydrolysis. However, the highest reduc-

ing power values of both hydrolysates were not obtained at the highest DH value but at 12 h for albumin, and 16 h for globulin (Wang and others 2008). Once again the lack of a direct relationship between antioxidant activity and DH suggested that the specific composition (such as type of peptides and ratio of different

free amino acids) is an important factor regarding antioxidant abilities.

Conversely, other researchers found that fractions with a higher degree of hydrolysis, produced peptides with a higher antioxidant activity (Wanasundara and others 2003; Liu and others 2010a). Porcine plasma hydrolyzed using Alcalase with a degree of hydrolysis of 17.6% had higher reducing power, iron chelating ability, and DPPH radical-scavenging activity compared to less hydrolyzed fractions (Liu and others 2010a), while defibrinated bovine plasma had the highest iron-chelating and thiobarbituric acid-reactive substances (TBARS) activity at 43% degree of hydrolysis. The ability of porcine plasma hydrolysates to chemically inhibit lipid oxidation as demonstrated in the study was attributed, in part, to protein structural changes. Nonhydrolyzed plasma proteins, possibly because of their compact structure, had low antioxidant activity when measured. Likewise, Chang and others (2007) found that Alcalase hydrolysates of porcine hemoglobin had higher DPPH radical-scavenging activities than that of the native hemoglobin (Table 10).

**Effect of peptides on the antioxidant activity.** Not much work has been done on sequencing peptides with antioxidant activity thus far. However, peptides of <3000 Da from porcine blood hydrolysates appear to have higher antioxidant activity than larger peptides in terms of reducing power, DPPH radical-, hydroxyl radical-, and superoxide radical-scavenging activities (Table 11). The antioxidant activity of porcine plasma hydrolysates, for example, was lowest for the peptide fraction above 10,000 Da. It has been suggested that the antioxidant ability of biopeptides *in vitro* depends on peptide size, amino acid composition of the peptide, and presence of free amino acids within the hydrolysates (Ryan and others 2011).

A recently published study used a nonenzymatic technique to produce porcine hemoglobin peptides at high temperatures (120 to 180 °C) and low pressures (4 MPa) under a nitrogen stream. Peptides presenting an average size of 3.2 kDa were obtained, with a yield of 84% with respect to the initial hemoglobin hydrolyzed. The main fraction of these peptides (40%) was composed of molecules smaller than 1 kDa, which possessed some good antioxidant properties (Álvarez and others 2012).

### Antimicrobial peptides from animal blood sources

Antimicrobial peptides are usually used to inhibit the growth of pathogenic bacteria. The agar diffusion assay (or inhibition zone assay) method is a common method used to test the antimicrobial activity of hydrolysates and peptides. The antimicrobial effect of a hydrolysate or a peptide increases in accordance with the diameter of the zone of inhibition formed. Peptidic solutions can be placed in wells made in the agar or on sterilized filter paper discs placed on agar previously inoculated with test bacteria. An accurate way to study the antimicrobial activity of hydrolysates and/or peptides is the determination of their minimum inhibitory concentration (MIC). The MIC value defines the lowest concentration of an antimicrobial that inhibits 100% of the growth of a microorganism, and it is usually determined by liquid growth inhibition in a 96-well plate spectrophotometric method (Fogaça and others 1999) or in a multi-tube system.

Antimicrobial peptides from animal blood have been studied quite extensively. A comprehensive review by Yu and others (2010) focused on antimicrobial peptides, including defensins and cathelicidins, found in the blood of animals relevant to the Australasian meat (cattle, sheep, pigs, goats, and deer) and poultry (chicken, turkey, and ostrich) industries. Livestock animals such as cattle,

pigs, goats, and sheep are more recently evolutionarily related and are thought to be more likely to contain similar antimicrobial defense systems (Tomasinsig and Zanetti 2005).

The mechanism of antimicrobial peptide activity is usually expressed by the disintegration of cell membrane, whereby the lipid bilayer of the cell membrane is the principal target. Interaction between the antimicrobial peptide and the cell membrane is an important requirement for antimicrobial activity. The majority of antimicrobial peptides that contain  $\alpha$ -helical structures are cationic and amphipathic, while others are also hydrophobic  $\alpha$ -helical peptides. The cationic properties of the peptide enable binding with the anionic phospholipid-rich membrane, which initiates cell lysis (Kitts and Weiler 2003). The determination of hydrolysis conditions in order to obtain peptides with desired molecular weights, which are able to adopt a  $\alpha$ -helical structure in contact with the bacterial membrane, is now of considerable interest. The micro-environment of the lipid bilayer has also been shown to have a stabilizing effect on the  $\alpha$ -helical structure of peptides (Adje and others 2011a) and is currently under investigation.

**Effect of enzymes and hydrolysis on the antimicrobial activity of hydrolysates from animal blood sources.** The use of enzyme hydrolysis to obtain antimicrobial peptides from animal blood is a relatively recent development starting with Froidevaux and others (2001). An antimicrobial peptide  $\alpha$ 1 to 23, active toward *Micrococcus luteus* A270, was isolated after enzymatic hydrolysis of bovine hemoglobin using pepsin. The initial identification of an antibacterial peptide sequence in bovine hemoglobin ( $\alpha$ 33 to 61) was actually first purified from the gut of a tick, *Boophilus microplus*, leading to the assumption that the proteolytic degradation of hemoglobin had taken place in the gut to provide a defense against microorganisms for the tick (Fogaça and others 1999).

Other methods used by researchers to obtain antimicrobial peptides from animal blood include crude extraction by lysing of cells or chemical treatment followed by separation of the peptide of interest using ion-exchange chromatography separation (bovine hemoglobin), or gel filtration chromatography (porcine neutrophils) (Hu and others 2010; Wessely-Szponder and others 2010). For antimicrobial peptides from sheep neutrophils, sonication of ovine white blood cells followed by gel permeation chromatography was utilized (Anderson and Yu 2003). Although some groups have reported that it is necessary to add neutrophil elastase to their crude cell extract to cleave the proregion and release the active peptides (Shamova and others 1999), the extraction process used by Anderson and Yu (2003) and Wessely-Szponder and others (2010) did not involve the addition of this enzyme. The latter authors reasoned that the cleavage was probably carried out by the neutrophil elastase naturally present in the crude extract.

The kinetics of the  $\alpha$ 1 to 23 peptide, which was the first antibacterial peptide to be isolated from bovine hemoglobin hydrolysate, was studied in the course of peptic hydrolysis at pH 4.5 and 23 °C in a homogeneous-phase system (Choisnard and others 2002). The kinetics of peptide appearance was investigated in acetate buffer alone and in urea as a hemoglobin-denaturing agent. Two different hydrolysis mechanisms, a “one-by-one” for native hemoglobin hydrolysis and a “zipper” for denatured hemoglobin hydrolysis were proposed. Regardless of the hemoglobin state, native or denatured, and the hydrolytic mechanism, one-by-one or zipper, the antibacterial  $\alpha$ 1 to 23 peptide was found to be a transient peptide. The amount of peptide produced in the presence of urea was twice as high as for the hydrolysis of native hemoglobin with the yields of  $\alpha$ 1 to 23 peptide being 55% and 25%, respectively (Choisnard and others 2002).

Table 10—Hydrolysis and antioxidant activities of animal blood hydrolysates.

Source	Protease	Hydrolysis time	Degree of hydrolysis	Reducing power	Iron-chelating ability (%)	DPPH radical-scavenging activity (%)	TBARS	Superoxide radical-scavenging activity	Reference
Porcine hemoglobin	No treatment	—	0%	0.38 ± 0.06%	74.87 ± 5.23	21.53 ± 1.98			Chang and others 2007
	Alcalase	4 h	7.6%	0.21 ± 0.00%	34.50 ± 0.96	51.57 ± 4.19			
	Flavourzyme	6 h	~18.7%*	0.08 ± 0.00%	33.96 ± 4.13	~2.81 ± 0.44			
	Alcalase + Flavourzyme	4 h + 6 h	13.4%	0.23 ± 0.01%	63.54 ± 3.69	41.94 ± 1.89			
Porcine hemoglobin	No treatment	—	0%			21.2 ± 1.61			Sun and others 2011c
	Flavourzyme	1 h	~3%*			~4*			
	Papain	1 h	~5.5%*			~18*			
	A.S. 1398	1 h	~4%*			~17*			
	Alcalase	1 h	~17%*			~27*			
	Pepsin	1 h	7.7%			67.0 ± 1.84			
Porcine albumin	Alcalase	12 h	~65%*	0.57* @ 700 nm					Wang and others 2008 Wang and others 2008 Wei and Chiang 2009
	Alcalase	16 h	~10%*	0.65* @ 700 nm					
	Trypsin	24				20.2 ± 1.0			
	Trypsin + Chymotrypsin + Thermolysin	10				64.9 ± 3.9			
Porcine plasma	Alcalase	10							Wei and Chiang 2009
	Trypsin	24				62.3 ± 1.8			
	Trypsin + Chymotrypsin + Thermolysin	24				11.5 ± 2.3			
	Alcalase	24				24.4 ± 2.4			
Porcine defibrinated blood plasma	Alcalase	24							Wei and Chiang 2009
	Trypsin	ND				30.8 ± 3.2			
	Trypsin + Chymotrypsin + Thermolysin	24				ND			
	Alcalase	24				22.4 ± 1.9			
Porcine blood plasma	No treatment	—	0%	456.4 ± 20.3 μM		23.4 ± 1.4			Liu and others 2009 Liu and others 2010a
	Alcalase	5 h	17.6%	1405.6 ± 7.6 μM		24.47 ± 0.10		20.04 ± 0.06	
	No treatment	—	0%	456.4 ± 1.4 μM		76.79 ± 0.02		63.99 ± 0.04	
	Alcalase	0.5 h	6.2%	713.1 ± 8.8 μM	5.62 ± 0.30	21.43 ± 0.09	2.05 ± 0.01 mg/L		
Porcine plasma (defibrinated)	No treatment	—	12.7%	1303.4 ± 8.2 μM	6.80 ± 0.62	31.16 ± 0.93	1.53 ± 0.01 mg/L		Xu and others 2009 Wanasundara and others 2003
	Pepsin	5 h	17.6%	1407.9 ± 9.9 μM	9.67 ± 0.30	45.14 ± 1.51	1.48 ± 0.01 mg/L		
	Papain	5 h			12.03 ± 0.52	76.53 ± 1.51	1.37 ± 0.01 mg/L		
	Flavourzyme	16 h			150% of EDTA	48.4			
Bovine plasma (defibrinated)	No treatment	—	0%	61% of EDTA		43.1			Wanasundara and others 2003
	Flavourzyme	16 h	13%	60.0		27.6			
	Flavourzyme	16 h	26%	95.0		28.8			
			43%	90.0		40.0			
				100		45.0			

\* Estimated values from figures available in corresponding reference.

ND, not detectable.

Note: Please refer to corresponding reference for protein concentration of hydrolysates used in the antioxidant activity tests.

Table 11 – Effect of peptide on antioxidant activity from animal blood.

Source	Peptide size (Da)	Reducing power ( $\mu\text{M}$ )	DPPH radical-scavenging activity (%)	Hydroxyl radical-scavenging activity (%)	Superoxide radical-scavenging activity (%)	Reference
Porcine plasma	<3000	1206.4 $\pm$ 31.5	70.07 $\pm$ 1.86			Liu and others 2010a
	3000 to 6000	866.6 $\pm$ 12.5	50.38 $\pm$ 2.06			
	6000 to 10000	664.9 $\pm$ 22.4	41.30 $\pm$ 1.23			
	>10000	557.3 $\pm$ 16.3	31.11 $\pm$ 1.07			
Porcine hemoglobin	<3000		83.4 $\pm$ 3.8	55.8 $\pm$ 2.2	27.8 $\pm$ 1.6	Sun and others 2011b
	3000 to 5000		66.7 $\pm$ 3.1	31.6 $\pm$ 2.8	18.1 $\pm$ 1.3	
	5000 to 10000		54.2 $\pm$ 2.0	22.3 $\pm$ 5.7	14.8 $\pm$ 0.8	
	>10000		69.9 $\pm$ 1.7	38.0 $\pm$ 4.6	11.9 $\pm$ 1.1	
Porcine albumin	<3000		~36*	33.8 $\pm$ 0.6	60.9 $\pm$ 0.9	Wang and others 2008
	3000 to 6000		~30*			
	6000 to 10000		~26*			
	10000 to 30000		~21*			
	>30000		~22.5*			
Porcine globulin	<3000		~26*	53.1 $\pm$ 0.4	72.5 $\pm$ 0.7	Wang and others 2008
	3000 to 6000		~20*			
	6000 to 10000		~16*			
	10000 to 30000		~12*			
	>30000		~29*			

\*Estimated values from figures available in corresponding reference.

The hydrolysis of bovine hemoglobin using pepsin was further utilized by Daoud and others (2005) to isolate another antimicrobial peptide at a low degree of hydrolysis (3%). The  $\alpha$ 107 to 136 peptide was the second antimicrobial peptide obtained by *in vitro* proteolysis of bovine hemoglobin. This peptide is active against 4 bacterial species: *Micrococcus luteus* A270, *Listeria innocua*, *Escherichia coli*, and *Salmonella enteritidis*.

The isolation and characterization of transient antibacterial peptides appearing in the course of bovine hemoglobin peptic digestion at a low degree of hydrolysis was further reported by the same group (Nedjar-Arroume and others 2006). A study of the time-dependent nature of peptic hydrolysis of bovine hemoglobin found that the released peptides detected during the early stage of hydrolysis (0 to 10 min) were all derived from the N- and C-terminal regions of bovine hemoglobin  $\alpha$ - and  $\beta$ -chains: from 1 to 46 and 99 to 141 regions of  $\alpha$ -chain; from 1 to 40 and 105 to 145 regions of  $\beta$ -chain. These regions possess relatively higher hydrophobicity. In the later stage of hydrolysis, pepsin hydrolyzed the middle part of the  $\alpha$ -chain from N- to C-terminal, while little enzymatic cleavage occurred in the center region of  $\beta$ -chain due mainly to the high hydrophilic nature. It was concluded that the terminal positions of these regions and their relatively higher hydrophobicity may play important roles in their greater susceptibility to pepsin hydrolysis, because pepsin preferentially cleaves exposed and hydrophobic peptide bonds (Su and others 2006).

Approaches to facilitate the production of only intermediate peptides after peptic hydrolysis of bovine hemoglobin with alcohols (40% methanol, 30% ethanol, 20% propanol, or 10% butanol), used to induce structural change of hemoglobin and to realize a limited hydrolysis, is a recent development and has shown that new antimicrobial peptides can be obtained this way (Adje and others 2011a).

**Effect of peptides on antimicrobial activity.** Several studies have been carried out isolating and sequencing antimicrobial peptides from bovine, porcine, ovine, caprine, and cervine blood (Table 12). The hydrophobicity of the peptide has been shown to be related to its antimicrobial activity, as higher hydrophobicity is useful in the binding of lipopolysaccharides on the outer cell membrane of the bacteria. Lopes and others (2005) have shown both the important role of tyrosine (Y) in the interaction with membranes, and the 2 positively charged amino acids, arginine

and lysine, which interact with negatively charged membrane phospholipids. Recent results from Catiau and others (2011a) showed that the peptide  $\beta$ 114 to 145 and its peptic derivatives containing the sequence RYH exhibited antibacterial activity. RYH was then chemically synthesized because hydrolysis did not result in this sequence. They concluded that RYH was necessary for the antibacterial activity and that the RYH is the minimal antimicrobial peptidic sequence required. The sequence of chemically synthesized peptide RYH contains both tyrosine and 2 positively charged amino acids, arginine and histidine. This may explain the highest antibacterial activity measured for this peptide in addition to the highest release of carboxyfluorescein from the liposome.

Meanwhile, KYR was the minimal sequence exhibiting an antibacterial activity from another study on the  $\alpha$ -chain of bovine hemoglobin (Catiau and others 2011b). Comparing the KYR sequence with the sequence RYH obtained from the  $\beta$ -chain of hemoglobin, both sequences contain tyrosine and 2 positively charged basic amino acids, including arginine. The authors concluded that tyrosine (Y), arginine (R), and one positively charged basic amino acid such as lysine (K) or histidine (H) are required for antibacterial activity (Catiau and others 2011a). However, other peptides from bovine hemoglobin, which do not contain tyrosine or arginine (Froidevaux and others 2001; Hu and others 2010) still demonstrate antimicrobial activity, suggesting another mechanism of action.

Both Wessely-Szponder and others (2010) and Anderson and Yu (2008) suggested that antibacterial peptides from animal blood neutrophils could be significantly more active in combination. It is therefore recommended that better therapeutic results could be obtained if isolated peptides were used synergistically.

## Other Blood Bioactivity Reported from Animal Blood Sources

### Opioid peptides

Opioid peptides are short sequences of amino acids that bind to opioid receptors in the brain. Hemorphins are a class of naturally occurring, endogenous opioid peptides, which are found in the bloodstream; they are derived from the  $\beta$ -chain of hemoglobin. Opioid peptides have an affinity for an opioid receptor and have

Table 12—Effect of peptide on antimicrobial activity.

Source	Peptide size (Da)	Amino acid sequence/Peptide name	Antimicrobial activity	Reference	
Bovine hemoglobin	1992.401	VNFKLLSHSLVTLASHL	<i>E. coli</i> O111 <i>S. aureus</i> NCTC4163 <i>C. albicans</i> 3135A <i>M. luteus</i> A270	10.3 ± 0.1 mm <sup>1</sup> 9.5 ± 0.1 mm <sup>1</sup> 7.6 ± 0.2 mm <sup>1</sup> 671 μM <sup>2</sup>	Hu and others 2010
Bovine hemoglobin	2236	α 1 to 23 VLSAADKGNVKAAWGKVGGHAAE	<i>E. coli</i> <i>L. innocua</i> <i>M. luteus</i> A270 <i>S. aureus</i>	35.27 μM <sup>2</sup> 35.27 μM <sup>2</sup> 39.2 μM <sup>2</sup> 39.2 μM <sup>2</sup>	Froidevaux and others 2001
Bovine hemoglobin		α 67 to 106	<i>E. coli</i> <i>L. innocua</i> <i>M. luteus</i> A270 <i>S. aureus</i>	35.27 μM <sup>2</sup> 35.27 μM <sup>2</sup> 39.2 μM <sup>2</sup> 39.2 μM <sup>2</sup>	Adje and others 2011b
Bovine hemoglobin	3152	α 107 to 136 VTLASHLPSDFTPAVHASLDK FLANVSTVLTSKYR	<i>E. coli</i> <i>L. innocua</i> <i>M. luteus</i> A270 <i>S. aureus</i>	76 μM <sup>2</sup> 38 μM <sup>2</sup> 76 μM <sup>2</sup> 76 μM <sup>2</sup>	Daoud and others 2005, Nedjar-Arroume and others 2006
Bovine hemoglobin	654	α 137 to 141 TSKYR	<i>E. coli</i> <i>S. enteritidis</i> <i>S. aureus</i> <i>L. innocua</i> <i>M. luteus</i> A270	9 μM <sup>2</sup> 4.6 μM <sup>2</sup> 1 μM <sup>2</sup> 1 μM <sup>2</sup> 9 μM <sup>2</sup>	Catiau and others 2011b
Bovine hemoglobin	768	β 140 to 145	<i>S. enteritidis</i> <i>E. coli</i> <i>L. innocua</i> <i>M. luteus</i> A270	18 μM <sup>2</sup> 45 μM <sup>2</sup> 45 μM <sup>2</sup> 18 μM <sup>2</sup>	Catiau and others 2011a
Bovine hemoglobin	2196	β 126 to 145 QADFQKVVAGVANALAHRYH	<i>S. enteritidis</i> <i>E. coli</i> <i>L. innocua</i> <i>M. luteus</i> A270	35 μM <sup>2</sup> 71 μM <sup>2</sup> 71 μM <sup>2</sup> 71 μM <sup>2</sup>	Nedjar-Arroume and others 2006
Porcine neutrophils	2154.5 1955.6 2055.5	Protegrin 1 Protegrin 2 Protegrin 3	<i>E. coli</i>	10 μg/mL <sup>2</sup>	Wessely-Szponder and others 2010
Ovine neutrophils		Peptide Pa/OaBac5	<i>E. coli</i> <i>S. aureus</i> <i>C. albicans</i>	4 μg/mL <sup>2</sup> 10 μg/mL <sup>2</sup> 10 μg/mL <sup>2</sup>	Anderson and Yu 2003
Caprine leukocytes	3375	ChBac3.4 RFRLPFRPPIRIH PPPFYPPFRRFL	<i>E. coli</i> ML35p <i>E. coli</i> ATCC 25922 <i>E. coli</i> M15 <i>P. aeruginosa</i> ATCC 27853 <i>L. monocytogenes</i> EGD <i>S. aureus</i> 710A MRSA ATCC 33591	2.3 ± 0.5 μM <sup>2</sup> 3.8 ± 1.5 μM <sup>2</sup> 6.0 ± 2.0 μM <sup>2</sup> 6.3 ± 2.9 μM <sup>2</sup> 2.8 ± 2.2 μM <sup>2</sup> 8.0 μM <sup>2</sup> 10.0 ± 3.7 μM <sup>2</sup>	Shamova and others 2009
Caprine leukocytes	5160.2	ChBac5	<i>C. albicans</i> 820 <i>E. coli</i> ML35p <i>E. coli</i> ATCC 25922 <i>E. coli</i> M15 <i>P. aeruginosa</i> ATCC 27853 <i>L. monocytogenes</i> EGD <i>S. aureus</i> 710A MRSA ATCC 33591	>16 μM <sup>2</sup> 1.6 ± 0.5 μM <sup>2</sup> 3.1 ± 1.5 μM <sup>2</sup> 4.7 ± 2.0 μM <sup>2</sup> 8.2 ± 2.9 μM <sup>2</sup> 2.8 ± 2.2 μM <sup>2</sup> >16 μM <sup>2</sup> >16 μM <sup>2</sup>	Shamova and others 2009 Shamova and others 1999
Cervine neutrophils	4460	Peptide P15	<i>C. albicans</i> 820 <i>E. coli</i> <i>S. aureus</i> <i>C. albicans</i>	>16 μM <sup>2</sup> 0.3 μg/mL <sup>2</sup> 1 μg/mL <sup>2</sup> 3 μg/mL <sup>2</sup>	Treffers and others 2005

<sup>1</sup> Inhibition zone of peptides.<sup>2</sup> MIC.

an effect on the nerve system (Pihlanto and Korhonen 2003). They also influence gastrointestinal functions. Typical examples of opioid peptides are endorphins, enkephalin, and prodynorphin (Arihara 2006). The isolation of 2 opioid peptides (hemorphins) from a bovine hemoglobin source through peptic hydrolysis was first reported by Piot and others (1992). On the basis of their study, they surmised that hemorphins are present in an inactive state within the intact β-chain of the globin protein sequence (Piot and others 1992). Hemorphins derived from hemoglobin have also

been reported to have inhibitory actions on ACE activity (Lantz and others 1991). In Table 13, examples are given of peptides (YPWT and YPWTQ) which demonstrated an opioid activity of IC<sub>50</sub> 45.2 μM and 46.3 μM, respectively, obtained from the β-chain of bovine hemoglobin (Zhao and others 1997).

The effect of the composition of the solvent on the peptic hydrolysis of bovine hemoglobin was studied to improve the preparation of 2 opioid peptides. Peptic hydrolysis was performed for 24 h at 23 °C in 0.1 M sodium acetate buffer, pH 4.5. The kinetics

Table 13—Opioid, mineral-binding, and antigenotoxic activity from animal blood.

Peptide/hydrolysates	Source	Enzyme treatment	Amino acid sequence	Activity	Reference
Opioid peptide	Bovine hemoglobin	Peptic hydrolysis	$\beta$ 34 to 37 and $\beta$ 34 to 38 (YPWT)	45.2 $\mu$ M (IC <sub>50</sub> )	Zhao and others 1997
Opioid peptide	Bovine hemoglobin	Peptic hydrolysis	$\beta$ 35 to 38 and $\beta$ 35 to 39 (YPWTQ) $\beta$ 31 to 40 (LVV-hemorphin-7) LVVYPWTQRF $\beta$ 32 to 40 (VV-hemorphin-7) VVYPWTQRF VSGVEDVN	46.3 $\mu$ M (IC <sub>50</sub> ) 29.1 $\mu$ M (IC <sub>50</sub> ) 34.3 $\mu$ M (IC <sub>50</sub> )	Piot and others 1992
Calcium-binding peptide	Porcine plasma	Flavourzyme with a 50:1 substrate-to-enzyme ratio (w/w) at 50 °C for 8 h	DLGEQYFKG	Ca binding 0.025 mM at a peptide concentration of 0.011 mM	Lee and Song 2009a
Iron-binding peptide	Porcine plasma	Flavourzyme with a 50:1 substrate-to-enzyme ratio (w/w) at 50 °C for 8 h	DLGEQYFKG	Fraction F222 had Fe binding of 0.056 mM at a peptide concentration of 0.021 mM	Lee and Song 2009b
Hydrolysates with antigenotoxic activity			-	Mean tail length, $\mu$ M:	Park and Hyun 2002
	Bovine plasma	Alcalase Neutrase Pepsin Trypsin		36.6 $\pm$ 11.5 60.9 $\pm$ 17.0 39.1 $\pm$ 9.1 70.4 $\pm$ 20.6	
	Bovine albumin	Alcalase Pepsin Trypsin		26.2 $\pm$ 7.1 27.8 $\pm$ 6.4 35.8 $\pm$ 9.3	
	Bovine globulin	Alcalase Pepsin Trypsin		50.8 $\pm$ 14.1 43.2 $\pm$ 11.0 51.4 $\pm$ 12.9	

of appearance of hemorphins was investigated in the presence of either 20% (v/v) ethanol, a stabilizing solvent of hemoglobin, or urea, a denaturing agent. Ethanol improved the yield of VV-hemorphin-7, whereas urea improved the yield of the 2 hemorphins. Because the amounts of hemorphins observed in urea were greater than in ethanol, the denatured state of hemoglobin is more favorable to obtaining LVV-hemorphin-7 and W-hemorphin-7. The peptide bonds that on hydrolysis give rise to hemorphins would be more accessible to pepsin. LVV-hemorphin-7 and VV-hemorphin-7 are produced not only at pH 2, during the peptic hydrolysis of bovine hemoglobin, as reported by several authors, but also at pH 4.5, at which pepsin is far less active. The peptic hydrolysis of bovine hemoglobin in the denatured state or in the native state in the presence of 20% (v/v) ethanol permits a significant increase in the production of these hemorphins (Lignot and others 1999).

### Mineral-binding peptides

Mineral-binding peptides, for example, caseinophosphopeptides (CPP), which have been generated from milk proteins, function as carriers for minerals, including calcium. CPP has also demonstrated anticarcinogenic activity (Saïd and Dominique 2011). Two mineral-binding peptides obtained from porcine plasma after hydrolysis with Flavourzyme have been reported (Lee and Song 2009a). A calcium-binding peptide had the sequence VSGVEDVN, while an iron-binding peptide had the amino acid sequence of DLGEQYFKG (Table 13). The level of binding ability of the 2 peptides was relatively similar.

### Antigenotoxic peptides

Hydrolysates from bovine plasma, globulin and albumin were tested for the antigenotoxicity potential (the ability to prevent damage to DNA) by measuring the reduction of DNA damage using the Comet assay (Park and Hyun 2002). Of the 4 enzymes used (Alcalase, Neutrase, pepsin, and trypsin), pepsin was the most effective protease for producing active peptides; and the peptic hydrolysate from bovine blood albumin was able to demonstrate the best antigenotoxic effect (Table 13). Antigenotoxic activities of the peptic hydrolysate of whole plasma and albumin increased when the treated concentrations were increased. The mechanism of action responsible for the antigenotoxicity activity of the peptides was not a direct chemical inactivation of the carcinogen MNNG, but a biological effect resulting from interaction with cells and changing the physiology or metabolism of detoxification. The aromatic amino acid residues, phenylalanine (F), tyrosine (Y), and tryptophan (W), were also thought to contribute to the antigenotoxic effect (Park and Hyun 2002).

### Bacterial growth-stimulating peptide

A peptide with a bacterial growth-stimulating activity was isolated from a bovine hemoglobin hydrolysate by reversed-phase high-performance liquid chromatography. Native bovine hemoglobin was produced by adding erythrocytes to water and 4 M hydrochloric acid, and 300 L 5% denatured hemoglobin at pH 2 was obtained. For peptic digestion, 80 L of this hemoglobin solution was heated to 40 °C in a reactor and pepsin was added.

Hydrolysis lasted for 8 h at pH 2.0, which was maintained by a pH-stat. The primary structure and molecular mass of the bioactive peptide, determined by amino acid analysis and fast-atom bombardment mass spectrometry, was identical to that of fragment 48 to 52 (STADA) of the  $\beta$ -chain of bovine hemoglobin. Microbiological tests in solid media demonstrated that this peptide exhibited growth-stimulating activity on Gram-negative bacteria. In the test group comprising enteric bacterial strains that colonize in an environment where hemoglobin is readily available, 7 of 10 strains of bacteria were stimulated by the peptide (Zhao and others 1996).

## Conclusions

This review presents detailed coverage of the literature available on bioactive peptides from animal blood, and it explores the possibilities of utilizing animal blood from the slaughterhouse industry for deriving such peptides, besides the conventional uses in food and other industrial applications. Blood from slaughterhouse animals is a readily available protein source. The utilization of animal blood from the slaughterhouse as described in this review offers economic, nutritional, and environmental benefits. As such, there is the need for more effort to be directed toward using this valuable by-product more fully to ensure that maximum benefits are derived. Research on the bioactive functions of peptides obtained from blood fractions should move toward targeting novel activities such as immunomodulatory activities.

It is well known that religious restrictions on the use of blood do exist. For example, both Islamic sharia'a and Jewish shechita are very clear on the prohibition of blood consumption, which may be a hurdle denying the use of whole blood in food for some cultures. However, the transformation brought about by the hydrolysis process may provide a way toward the acceptability of blood-derived products. Religious opinions from scholars are yet to be presented.

The extent of hydrolysis of blood, as determined by degree of hydrolysis (DH), and the potency of bioactive peptides can be influenced by the choice of enzyme, the hydrolysis conditions including enzyme-to-substrate ratio, temperature, pH, and hydrolysis duration. Peptide size and amino acid sequence also contribute to differences in bioactivity. These critical control points must be studied and understood to derive the best activity or peptide. However, as most studies have only looked at the bioactivity of blood-derived peptides *in vitro*, further experiments are required to evaluate the effectiveness of these activities *in vivo*. This review of research conducted to date gives a strong indication that slaughterhouse blood is a good source of protein with the potential to provide many bioactive compounds.

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## Slaughterhouse pest control

In recent years, food safety issues have attracted global attention, and pests problem is that a slaughterhouse needs to face seriously. Slaughter is a process of killing livestock, poultry, and producing meat for human consumption. The slaughterhouse requires very high standards of production environment to ensure the safety of meat, which is to ensure the safety of our human beings.

es in slaughterhouse, it will affect the health of the slaughter workers. As a place for meat production, the pests management is particularly important for the slaughterhouse . Traditional fly traps and sticky fly strips cannot quickly eliminate flies. The flies have a strong ability to breed. We cannot imagine the consequences, if the pests are not effectively prevented and controlled in short time. Therefore, before the meat enters the market, the slaughterhouse must solve the pest problem during the slaughtering and storage process. Animals' secretions and excretions are the foods that flies love, flies like to lay eggs on meat, which can seriously contaminate the meat after slaughter, thus affecting human health. The environment of the slaughterhouse is very conducive to the breeding of pests. If you do not carry out long-term prevention and control, all you have done before is futile. The traditional fly board need replace frequently, and it takes time and labor. As a result, fly management is particularly important in slaughterhouses.

[Inquiry Online](#)

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**Pestman can provide a complete solution for the slaughterhouse to effectively solve the pest problems and provide a safe and hygienic slaughter and storage environment.**

1. Pestman fly control products can be evenly placed on the periphery of the slaughterhouse to form a barrier to prevent outdoor flies from entering the slaughterhouse, and to lure the flies from the workplace to the outside.
2. Pestman housefly control products can lure house flies into traps by light that is attractive to house flies, and let them die naturally in a short period of time.
3. The effective duration of Pestman fly control products are longer, and can be used for long-term prevention and control for 6~18 months. The replacement is not too frequent, saving labor and time.



**ADVANTAGES OF PESTMAN PRODUCTS**

**01**

Non-toxic, no pesticides

**02**

High efficient and safety

Long effective duration

## Relative Products



### Blow Fly Attractant

The product is made from the blow fly's favourite food ingredients and has a strong attraction to blow flies, can lure flies within 100 meters. The product is non-toxic, through...

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### House Fly Bait

The fly bait is scientifically formulated and processed by imidacloprid, flour, sugar, attractant and feeding stimulant. It is a special attractant for house fly and has strong attractio...

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## Fly Trap

Pestman Fly Trap contains very strong effective fly bait, and it can lure Flesh fly (Sarcophagidae), Blow fly (Calliphoridae), Flower fly (Anthomyiidae) and other flies...

[VIEW MORE](#)

## Relative Solution



### **Poultry farm pest control**

Modern poultry farms use intensive farming techniques and high-density poultry are concentrated. In summer, the temperature and humidity are high, which is highly prone t...

[VIEW MORE](#)



### **Countryside pest control**

In some countries, because of the poor economic situation and the little attention of the environment. The sanitary status of the countryside is worse than city. In addition, the...

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## **Relative Cases**



## The field trial of Pestman house fly bait in poultry farm

Pestman cooperated with Yinlian chicken farm Shengzhou, Zhejiang, China. We applied Pestman house fly bait in the chicken farm and conducted regular observations. The...

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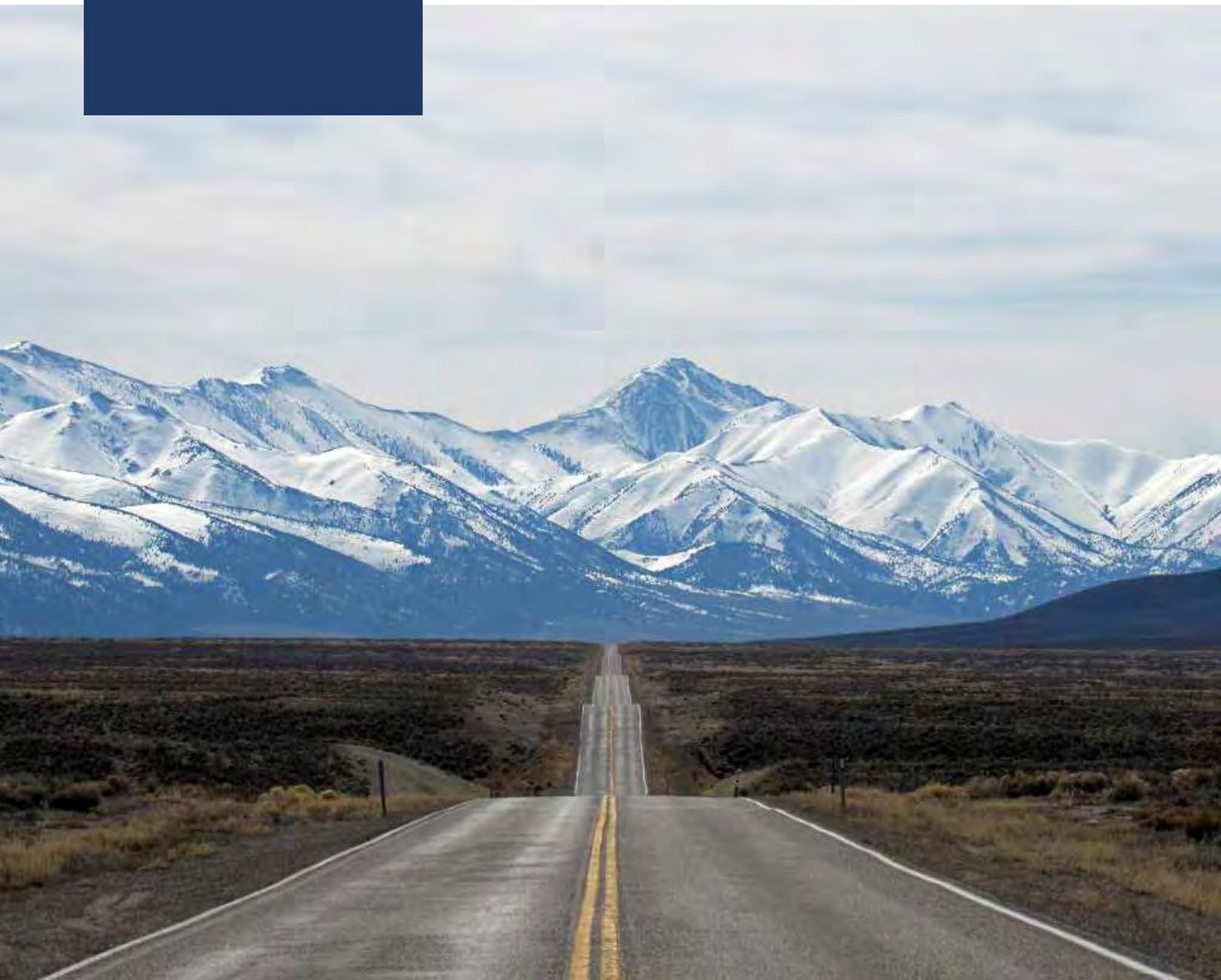
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The Future Beyond the Pandemic

NEV  
GOVERNOR'S  
OFFICE  
ECONOMIC  
DEVELOPMENT

# Nevada's Plan for Recovery and Resilience

Prepared by **SRI International**, in collaboration with  
RCG Economics and Brookings Mountain West



## Authors

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## Note

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Photo Courtesy of vtravelled.com/Flickr

# Executive Summary

## Nevada's Plan for Recovery & Resilience

### Vision

| *A diverse innovative and sustainable economy*

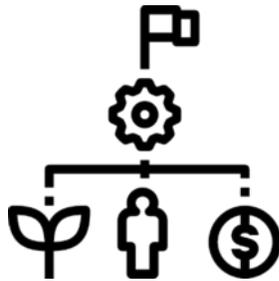
### Mission

| *Good jobs today better jobs tomorrow*

## Executive Summary

# Priority Areas for Immediate Intervention

GOED has targeted a variety of coordination information and leadership challenges in order to accelerate immediate recovery



Resources for People and  
Businesses



Business Support and  
Expansion



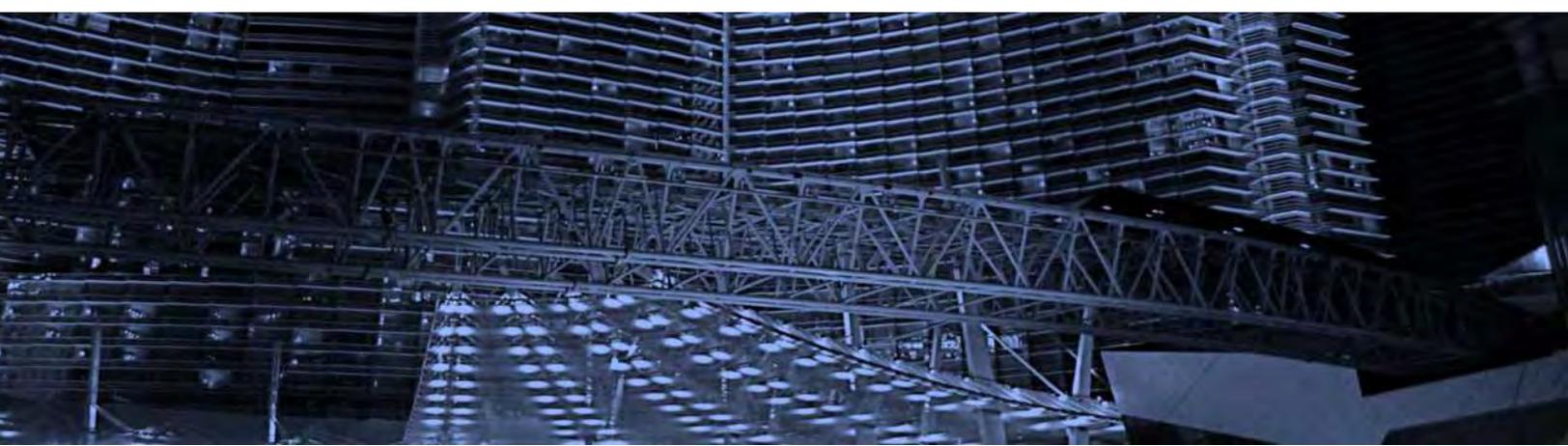
Workforce for the Next  
Economy



New Technology  
Businesses



Data and Integrated  
Planning for Decision-Making



## Executive Summary

# Visionary Strategies and Initiatives

GOED works with stakeholders to pursue visionary policies that set Nevada apart for the future



Regionally Designed Industrial Clusters



Statewide Integration and Connectivity

---

Develop New Approaches to Cluster Identification and Development

---

Integrate and Expand Capabilities between Northern and Southern Nevada

---

Integrate into Regional and Global Value Chains

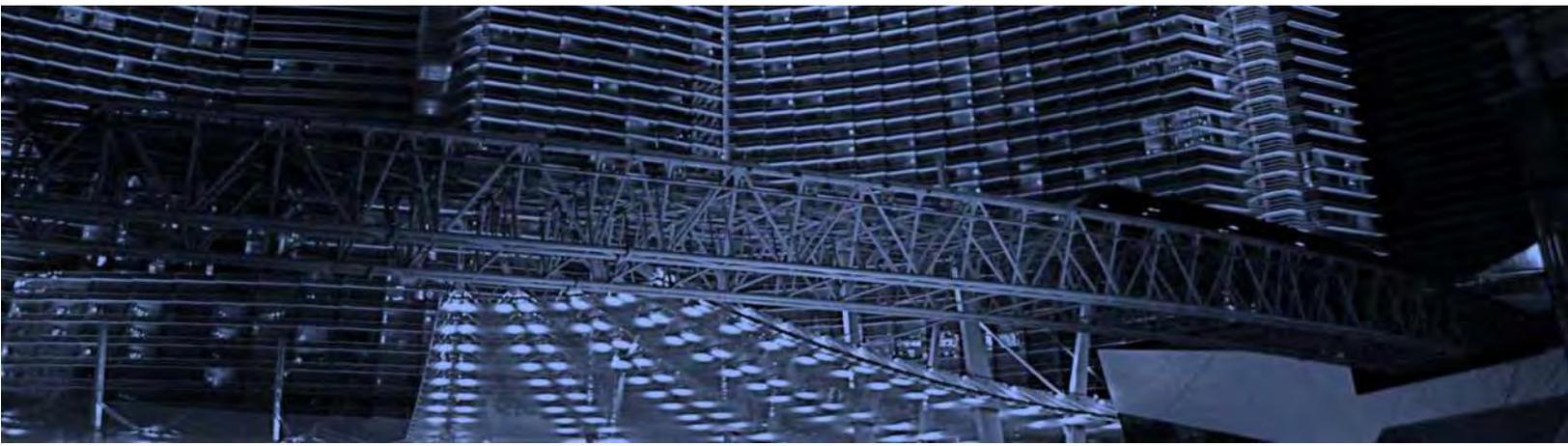
---

Expand Broadband Accessibility

---

Enable Further Diversification of Southern Nevada's Economy

---





Technology Driven  
Development



Responsible and Sustainable  
Growth

---

Establish Southern Nevada as a World Data  
Hub

Lead the Global Development of Energy  
Storage Supply Chains

---

Recruit Automation and Digital Technologies  
Firms

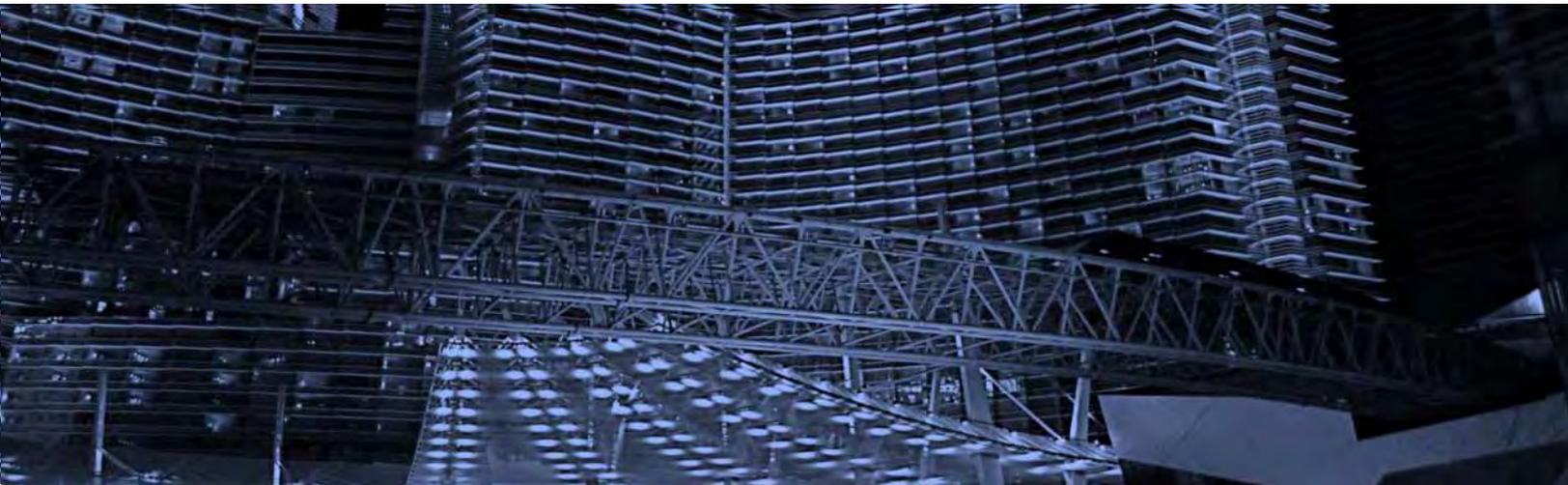
Transition to a Low-Carbon Low-Emission  
Economy

---

Enable Technology-Based Entrepreneurship

Transition to a Water-Wise Economy

---





## Comprehensive Placemaking

---

Remove Barriers to Increased Healthcare Access across Nevada

---

Encourage Purposeful Residential Zoning and Development

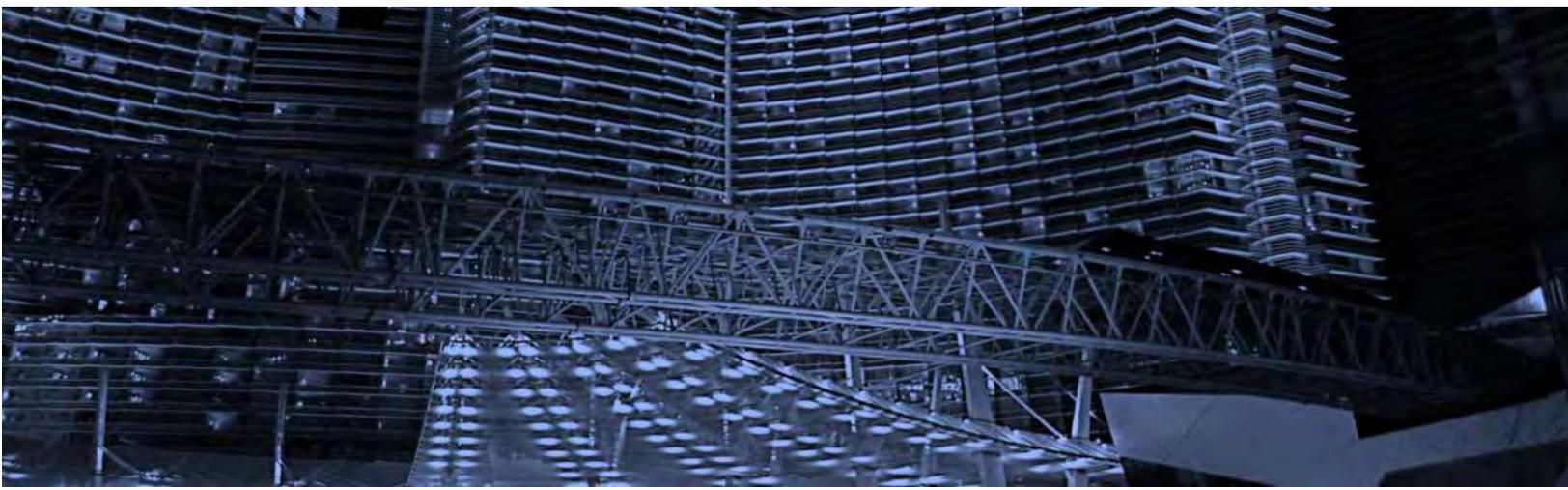
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Increase Engagement with Outdoors for Business and Leisure

---

Support Entrepreneurship in Digital Arts and Esports

---



## Executive Summary

# Capabilities to Realize the Vision

Nevada will need to build or rebuild key financial and institutional capabilities and develop realistic statutory actions



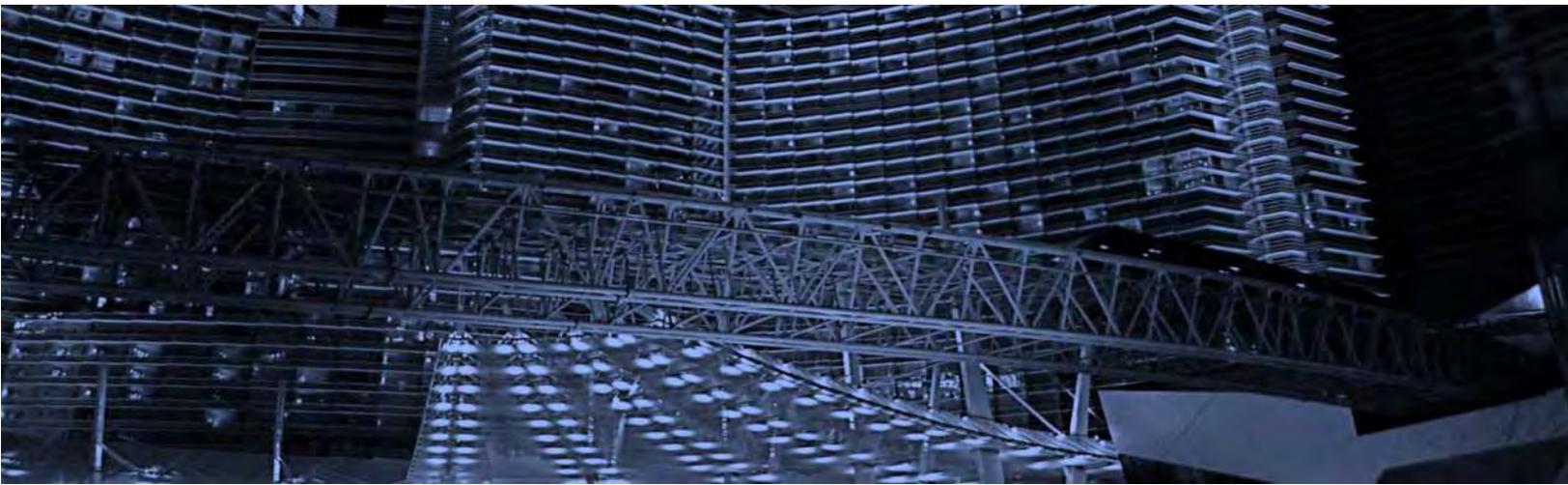
Fund the State Infrastructure Bank



Establish a Sovereign Wealth Fund



Establish the Nevada Innovation Fund





Establish an Office for  
Micro-, Small-, and  
Medium-Sized Enterprises



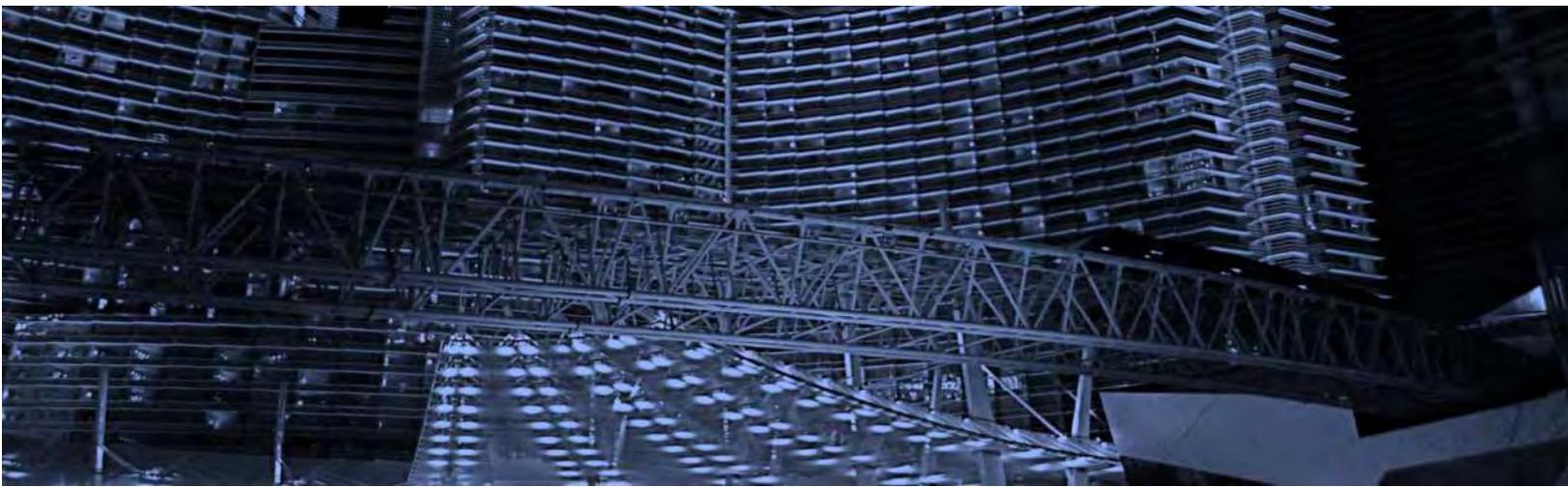
Grow Nevada's Community  
Banking Network



Modernize Public Policy  
and Governance



Reinvent Nevada's  
Workforce Institutions



## Executive Summary

# Nevada's Assets

## Innovation Ecosystem and Economy

In 2014, SRI International conducted a statewide assessment of Nevada's assets, examining those within the domains of the innovation ecosystem, economy, physical infrastructure, quality of life, governance, and natural resources.

### Innovation Ecosystem

- + Entrepreneurial and risk-taking population
- Coordination lacking among the state's innovation system

### Economy

#### Diversification of Economic Base

- + Shift from tourism and gaming towards high-skill industries
- Many jobs added in lower-skill elements of high-skill industries

#### Skilled Workforce Attraction/Retention

- + Attraction of many historically underrepresented occupations
- Highly educated spouses unable to find jobs in some areas

## Executive Summary

## Nevada's Assets

## Physical Infrastructure

## Physical Infrastructure

## Energy

- + Significant renewable energy integration into electrical grid
- Dependent on imports for fuel to meet energy needs

## Broadband

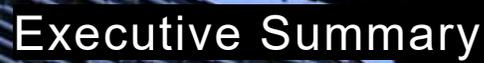
- + Strong connectivity and high speeds in metropolitan areas
- Weak connectivity and lack of redundancy in rural communities

## Transportation

- + Strong air and road connectivity in major metropolitan areas
- Lack of consistent funding for roads that require significant repairs

## Housing

- + New home builds increasing throughout the state
- New homebuyers increasingly priced out in metropolitan areas

Executive SummaryNevada's AssetsQuality of LifeQuality of LifeHealth

- + Positioned for significant growth in healthcare
- Continuing shortage of medical professionals

Safety

- + Significant progress in reducing property and violent crime
- Crime still a pervasive issue in many communities

Education

- + K-12 education system contains nationally-ranked high performers
- Underperformance a result of underfunding and overcrowding

Recreation

- + Open land for exploration and outdoor recreation
- Ability to attract families harmed by an incomplete image of the state ("Sin City")

## Executive Summary

# Nevada's Assets

## Governance

### Governance

#### Institutional Assets

- + Responsive state and local offices for economic development
- Weak enterprise technologies and limited financial capacity

#### Taxation

- + Low-tax environment attractive to business
- Low-tax environment limiting to investments that could attract businesses

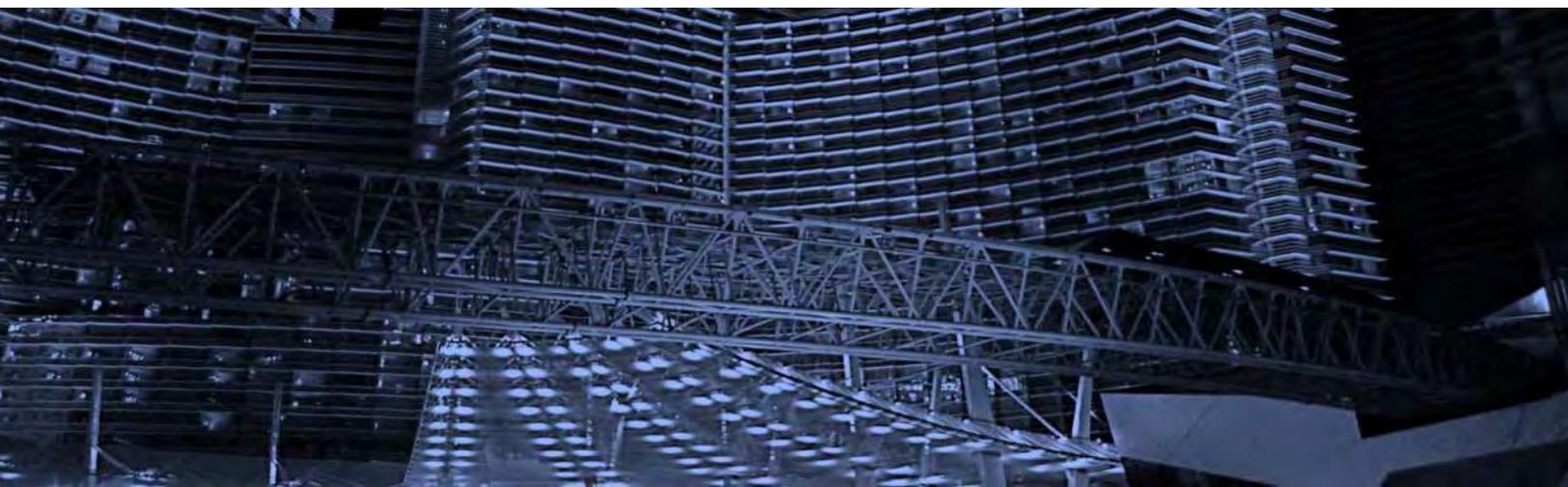
#### Business-Friendly Environment

- + Easy access to decisionmakers
- Tax abatements not meeting the needs of technology companies
- Limited banking sector

# Executive Summary

# Nevada's Assets

## Natural Resources



## Executive Summary

## SWOT Analysis

## Strengths

The SWOT analysis highlights sources of strength and weakness that may be addressed opportunities to be realized and dangers and difficulties to be avoided

 **Strength**
**Culture and Quality of Life**

- Enterprising migrants
- Frontier spirit
- Artists, musicians, and performers
- Outdoor enthusiasts

**Governance**

- Low taxes and regulation
- “Small state” advantage

**Industry**

- Increasing diversification
- Value-chain opportunities

**Infrastructure**

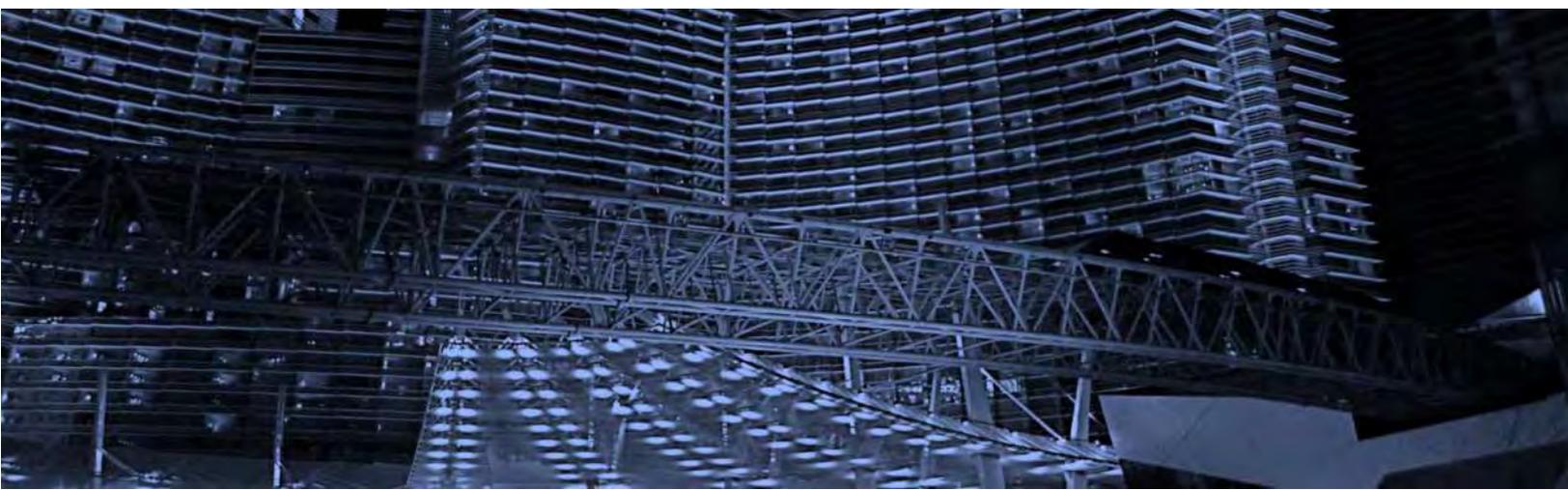
- Inexpensive energy
- Increasing use of renewable energy
- Advanced water management
- Urban connectivity
- Stable environment

**Innovation**

- Connections to the West Coast
- Low barriers for new businesses
- Pervasive small business ethic

**Workforce and Education**

- Established models of success
- Workforce Innovations for a New Nevada (WINN) and other career and technical education (CTE) booster programs



## Executive Summary

## SWOT Analysis

## Weaknesses

**Weakness****Innovation**

- Immature mentor networks
- Lack of early-stage funding
- Underutilized tools and programs
- Weak connections to research institutions

**Infrastructure**

- Energy market uncertainty
- Water rights
- Rural broadband connectivity
- Congestion in suburban and urban areas
- Federal land ownership

**Governance**

- Tax abatements
- Property tax limitations
- Impact of the Knowledge Fund
- Economic development collaboration

**Culture and Quality of Life**

- Housing affordability
- Low trust in government institutions
- Lack of collaboration
- Poor health indicators
- Harsh desert climate

**Workforce and Education**

- Weak institutional performance
- Lack of K-12 and higher education funding
- Low educational attainment
- Poor career guidance for mid-skill workers
- Shortages in building and other skilled trades

**Industry**

- Persistently low wages

Executive Summary

# SWOT Analysis

## Opportunities and Threats



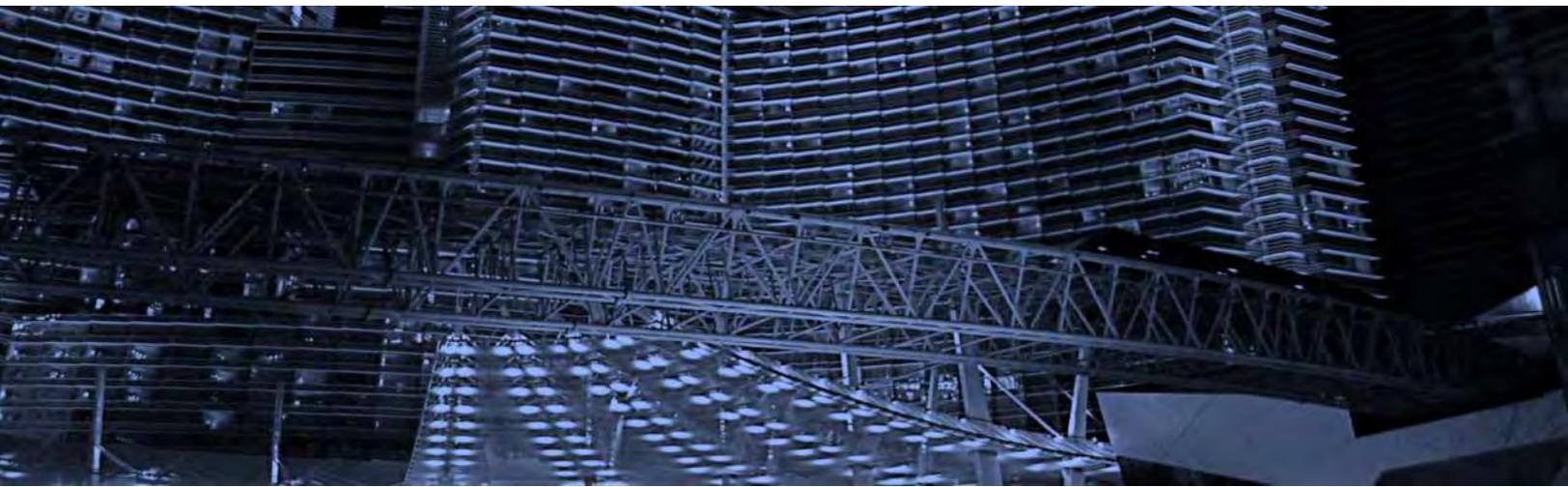
### Opportunity

- Access to West Coast networks
- Access to Mountain West markets
- Las Vegas world brand
- Opportunities for mining diversification
- Testbed for new technologies
- Mobile Millennials and Generation Z
- West Coast costs and congestion



### Threat

- Impact of climate change
- Exposure to economic cycles
- Uncertain federal policies
- Competition from Mountain West states
- Costs and congestion





## Nevada's Plan for Recovery & Resilience

# Overview

## The Future Beyond the Pandemic

Photo Courtesy of Bob Wick/BLM/Flickr

## Overview

The report that follows contains the following components:

- An economic forecast from RCG Economics on the situation expected for Nevada—GDP and employment—in the fall of 2020 subject to all the present uncertainties faced by Nevada and the country as a whole
- A series of immediate actions in which GOED plays a leadership role to shelter and prepare for recovery key components of Nevada's economy. The particular focus is on "Main Street" and small and medium sized businesses
- A set of visionary strategies firmly grounded in Nevada's underlying assets that will accelerate the diversification of the state's economy and the transition towards technology intensive and skill intensive employment
- An inventory of necessary capabilities that must be developed or upgraded in order to realize the vision of a diversified, innovative, and sustainable economy

The report constitutes an agenda for the whole state, urban and rural, for which GOED plays a critical coordinating role. However, GOED operates only as a partner with other stakeholders within each region and across the state. As the SWOT analysis above suggests, policy fragmentation is an

enduring challenge for Nevada. The plan is designed to address this challenge directly by providing a high-level agenda that will coordinate the actions of a broad set of partners—public and private.

Over the last years, Nevada has made significant strides in recovering from the Great Recession of the late s, exceeding expectations and growing new industries that provide opportunities for all Nevadans. This is in no small part due to the statewide economic development strategic plan released in *Moving Nevada Forward: A Plan for Excellence in Economic Development* and the supporting assessment *Unify, Regionalize, Diversify: An Economic Development Agenda for Nevada*, both of which aimed to modernize the state's approach to economic development and lift it out of the Great Recession.

Under the direction of this plan and the leadership of the Governor's Office of Economic Development (GOED), Nevada has made significant progress in diversifying its economy. However, the COVID- pandemic has put an extraordinary strain on public health and economic systems in Nevada and around the world, and brought about another recession. Once again, Nevada is uniquely exposed. The state's economy is historically procyclical, and the impact of the pandemic on travel and hospitality worsens this exposure.

While recommendations for social distancing and stay-at-home orders have been highly effective at limiting the spread of the virus and saving lives, the impact on consumer spending has been severe. In particular, the leisure and hospitality industries have experienced unprecedented contraction, with most resorts and venues closed for many weeks, and workers facing prolonged uncertainty.

The reality is that some of Nevada's workers will not return to the same job that they had before the COVID- pandemic—either because of business closure, lack of customers, or drop in demand for certain industries. Small- and medium-sized businesses have been especially hard hit, and their losses will delay a strong recovery. On the other hand, other industry sectors will see growth as Nevada and the nation recover from the economic impact.

Economic activity over the next to months will require close collaboration between the state's employers and state and local government to ensure that the gradual lifting of pandemic restrictions does not lead to an uncontrolled increase in COVID- cases. In addition, state and local leaders must understand the challenges the state will face in the medium term. As with the Great Recession, consumer confidence—which sustains travel, hospitality, and entertainment—will be slow to return, no matter what political leaders say. Fostering this confidence will require a visible change in business practices.

*Nevada needs an economic Dunkirk:  
Economic development initiatives and  
workforce programs must rescue businesses  
and workers immediately by mobilizing all  
available state and private sector resources*

In order to support this reopening, GOED will work with stakeholders—elected officials, business organizations, workers, and employers—to target immediate recovery and long-term resilience. As Nevada's leaders begin to reopen the state's economy, GOED's actions should serve the immediate needs of business in order to accelerate the reopening in line with the public health response. At the same time, GOED will start to map key changes for the future for which business will need to be prepared.

In short GOED will target **immediate recovery** and **long-term resilience**. This plan along with immediate and long-term efforts to recover and reimagine Nevada's economy will be completed through collaborative efforts between state and local leaders, stakeholders from the business community, higher education, and workers. Importantly, with an ongoing pandemic, there can be no "return to normal" or economic recovery without a public health recovery.

## Immediate Recovery

The reopening will be driven by the reasonable urgency of businesses trying to get back on their feet. A variety of coordination, information, and leadership challenges are being addressed to make it as fast and smooth as possible, and GOED has a critical role to play in meeting these challenges.

## Long-Term Resilience

Once reopening has occurred, the "new normal" will be different. State and local government has a special responsibility to support business under these changed conditions, as well as a responsibility to design and pursue policies that set Nevada apart for the medium term.



Nevada's Plan for Recovery & Resilience

# Economic Forecast

The Future Beyond the Pandemic

Photo Courtesy of Trevor Bexon/Flickr

## Economic Forecast

The plan that follows is grounded in a high-level 12- to 18-month economic and fiscal analysis and projection for the state of Nevada and its two metropolitan statistical areas (MSAs) based on three economic/fiscal scenarios and projections: Best, Most Likely, and Worst Case. Tables depicting these projections not included below are made available in Appendix D. Several datasets were utilized to generate the model's results, including:

- Total employment
- Initial unemployment claims
- Visitor volume
- Taxable retail sales
- U- headline unemployment rate and workforce participation rate
- Sales and use tax collections
- Aggregation of other relevant tax revenues

## Results

In this section, RCG Economics presents and discusses its forecast results for this study's selected indicators. The discussion here is also focused on how the forecasts relate to the assumptions used.

in their formulation assumptions outlined below. For a deeper discussion of these assumptions and how the forecasts were produced, please see *Methodology*. The indicators discussed in this section relate to:

- Gross domestic product (GDP)
- Employment
- Unemployment
- Visitor volume
- Taxable sales
- Property tax
- Gaming tax
- Room tax
- Sales & use tax
- Consolidated tax
- Modified business tax
- Marijuana excise taxes

RCG has developed three forecast scenarios for each indicator. They are listed below, based on RCG’s research. Additionally, the study discusses and compares the forecast results against a no-pandemic scenario—a hypothetical forecast that assumes that the COVID-19 pandemic did not occur:

- No Pandemic
- Worst Case
- Most Likely Case
- Best Case

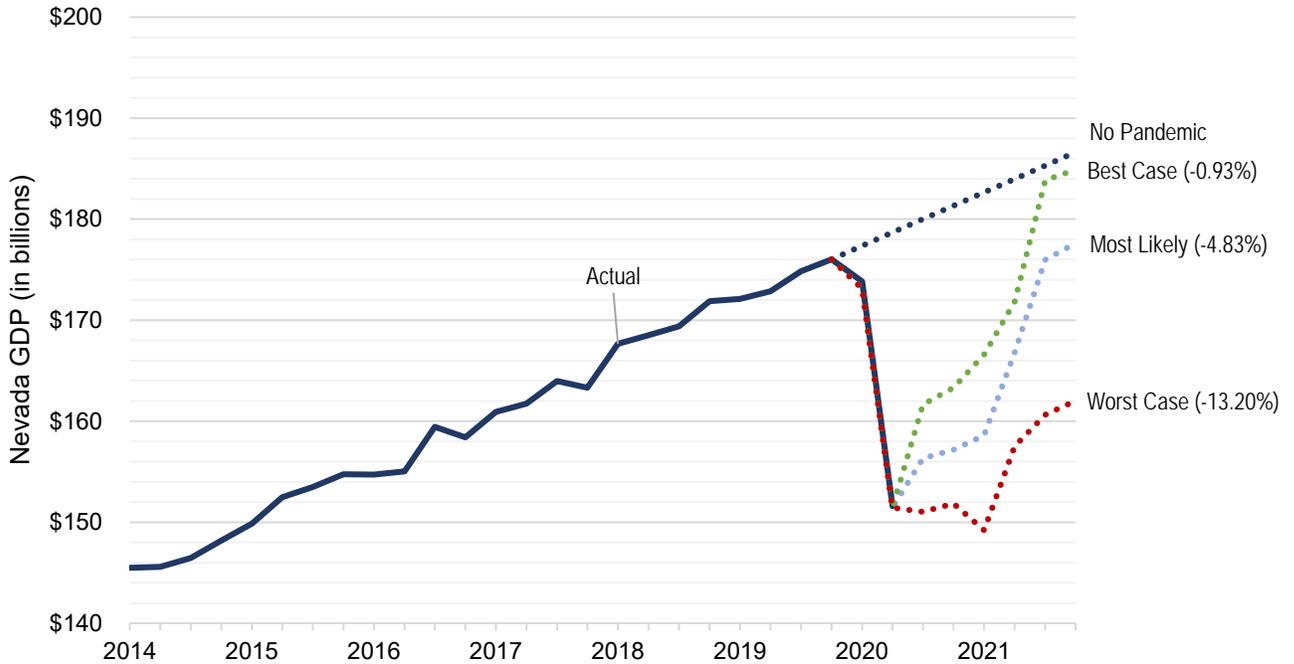
## **GDP**

### Total GDP

**The Most Likely scenario of RCG’s Nevada GDP model is based on a 10.5% decline in Q2 2020 compared to Q2 2019.** This large drop is not surprising considering that Nevada has been hit hard by the pandemic compared to most other states because of its largely tourism-driven economy, especially the Las Vegas MSA. The statewide economic lockdown in the early months of the pandemic especially affected the tourism industry, about 10% of the state’s economy. Seasonally adjusted jobs in the industry dropped by 10% or by 10,000 jobs from 100,000 to 90,000 between April 2019 and April 2020 as result of the lockdown that began on March 2020. By June, the industry had regained 50% of the jobs lost in April.

## The COVID-19 Pandemic Severely Impacts GDP Growth in Nevada

Figure 1: Nevada Real GDP Forecasts by Scenario 14 to 1 Source: RCG Economics and U.S. Bureau of Economic Analysis



**Note:** Data are in U.S. Dollars. The solid blue line “actual” represents historical GDP data from Q1 14 to Q4 19. The dotted dark blue line provides the results of the authors’ no-pandemic scenario, a forecast that assumes that the pandemic had never occurred. The dotted light blue line provides the results from the study’s Most Likely case scenario, the most likely outcome based on the authors’ research. The dotted green line represents the Best-Case scenario. In this case, the factors included in the model generally see relatively optimistic outcomes. The dotted red line shows the Worst-Case scenario, in which the model’s factors were given relatively poor outcomes. Data in parentheses represent the forecasted change in GDP from the expected GDP under the no-pandemic scenario in Q4 19. Forecasted GDP change by sector can be found in Table 1.

In the Most Likely scenario, by the end of 2021, it is expected that the state’s GDP will be \$155 billion in 2021 dollars, or 4.83% less than what it hypothetically would have been had the pandemic not occurred. However, in the Worst Case, it is projected that Nevada GDP could fall to as low as \$145 billion, similar to the state’s GDP in Q1 14. This represents a 13.20% loss in GDP compared to the no-pandemic scenario. Such a drop in GDP would significantly impact the state’s economy. It would potentially take years, possibly a decade or more, for the economy to return to its pre-pandemic growth path.

On the other hand, the Best-Case scenario projects that the pandemic does not ravage the state’s economy. In this scenario, state GDP in Q4 21 is projected to be \$165 billion, or only 0.93% below the no-pandemic scenario. In this case, Nevada’s economy would be able to recover from the COVID-19 pandemic in a relatively short period of time.

For the Best-Case scenario to actually occur, Nevada, like other states, would require the federal government to provide an additional tranche of virus-related financial relief, including continued and substantive unemployment benefits to workers, direct aid to states and local governments.

additional paycheck protection program dollars to small businesses and at some point large-scale infrastructure investments. This would require the federal government to add several trillion dollars to the national debt but would likely protect the U.S. economy from a continued free-fall and accelerate its recovery from possibly decades to a few years. Such a scenario would also require the severity of COVID-19 in Fall and Winter to remain constant relative to the summer months. This will allow governments to continue to reopen the economy more fully and safely and lessen consumer fears and uncertainty about leaving their homes and self-quarantining. However, based on the experiences of New England in early-2020 and southern Brazil in mid-2020, this is not a given.

The Worst-Case scenario for the state assumes a series of negative events to happen. First, COVID-19 hospitalizations and deaths in the state would increase such that the Las Vegas metropolitan area would potentially look like New York City in March 2020: almost overwhelmed by infections. This would likely trigger a second lockdown. It is suspected that this would also heighten fears relative to COVID-19 and lead to higher levels of sheltering in place, compounding the effects of a potential lockdown. The Worst-Case scenario also assumes a continued deadlock on Capitol Hill and no further enhanced federal unemployment insurance benefits to workers. The continued absence of these benefits would represent a significant loss of personal income and, therefore, potential GDP. On the positive side, a potential political stalemate of this order would be unlikely—even in an election year—should COVID-19 deaths spike nationwide. Other factors, such as the Paycheck Protection Program, were included in the scenario assumptions and are described in greater detail in the *Methodology* section.

In the Most Likely scenario, it is assumed that Q3 2020 will experience a minor surge in COVID-19 deaths. In this case, Nevada will probably return to Governor Sisolak’s Phase 2 guidelines for three months but not experience a full lockdown, also referred to as Phase 3. It is assumed that the preference by a large share of Nevada residents to shelter in place will remain relatively unchanged compared to Summer 2020 levels and will again decline further in Spring 2021. This also assumes that the COVID-19 vaccine will be widely manufactured and distributed at an affordable price by the middle of 2021. Should the Most Likely scenario evolve, the economic forecast for Nevada will look a lot more like the Best-Case scenario than the Worst-Case scenario.

Forecasts for the MSAs have not been included in this analysis because the Nevada sub-state data for the most recent year appear to have problems. The Reno-Sparks MSA shows negative growth which does not appear accurate. According to GOED, the issue stemmed from certain accounts being recorded as located in the Las Vegas MSA while the activity actually took place in the Reno-Sparks MSA.

### Sector GDP

In terms of GDP by sector, a range of various outcomes was found that can be seen in the following tables. Accommodation and Food Services shows the widest possible range of outcomes at the end of 2020, from 15% less than the No-Pandemic scenario in the Best Case to 45% less in the Worst Case. The Most Likely scenario shows a 25% change. Table 1 provides the forecasted change for selected sectors of Nevada’s economy based upon the expected growth under the No-Pandemic scenario. As can be seen, though Accommodation and Food Services experiences the largest variation in possible outcomes, Arts, Entertainment, and Recreation, which represents a significant portion of Nevada’s economy, also demonstrates high levels of variation between the best and worst cases.

**The Most Likely Scenario Forecasts a Moderate Reduction in Most Sectors, but Sharp Contractions Remain for Nevada’s Dominant Sectors**

Table 1: Forecasted Change in Sector GDP in Q4 1 Compared to Expected Growth Under No-Pandemic Scenario  
Source: RCG Economics

Sector	Best Case	Most Likely	Worst Case
Accommodation and Food Services	- %	- %	- %
Arts Entertainment and Recreation	- %	- %	- %
Construction	- %	- %	- %
Healthcare and Social Assistance	- %	- %	- %
Professional Scientific and Technical Services	- %	- %	- %
Total GDP	- %	- %	- %

**Taxable Sales**

For taxable sales the three geographies analyzed showed similar outcomes at the end of see Table Statewide the Worst-Case forecast shows a drop in taxable sales of about % worse than the drop in Washoe County % but not as severe as the drop in Clark County % In the Most Likely scenario however the drops are much less severe for Nevada % Clark County % and Washoe County % though still notable particularly for Clark County In the Best Case neither Nevada Clark County nor Washoe County experience a drop in taxable sales greater than %

**Washoe County’s Reduced Dependence on Tourism and Entertainment Softens the Comparative Impact of the Pandemic on the Region’s Taxable Sales**

Table : Forecasted Change in Taxable Sales in Q4 1 Compared to Expected Taxable Sales Under No-Pandemic Scenario Source: RCG Economics

Geography	Best Case	Most Likely	Worst Case
Nevada	- %	- %	- %
Clark County NV	- %	- %	- %
Washoe County NV	- %	- %	- %

**Employment**

The results for employment show outcomes for that look much like those for taxable sales In this case the Las Vegas MSA would fare worse than the Reno-Sparks MSA in each case In the Worst-Case scenario the state would experience a % decline relative to the No-Pandemic case The Las Vegas MSA would see an % drop and the Reno-Sparks MSA an % drop In the Most Likely scenario the regions ranged from a drop of % to % Table below provides an overview of the changes in employment for each of the three geographies

## Forecasted Changes in Employment Demonstrate the Comparative Resiliency of Northern Nevada’s Economy Compared to Other Regions of the State

Table 3: Forecasted Change in Employment in Q4 1 Compared to Expected Employment Under No-Pandemic Scenario  
Source: RCG Economics

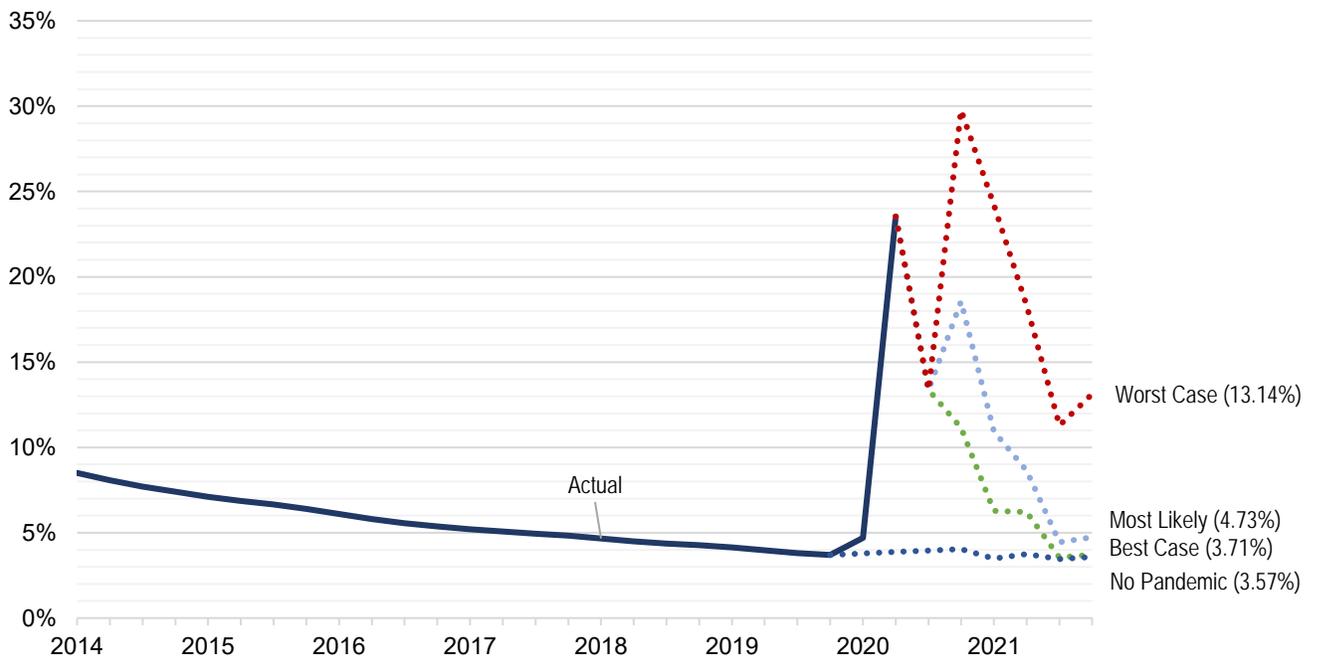
Geography	Best Case	Most Likely	Worst Case
Nevada	- %	- %	- %
Las Vegas MSA	- %	- %	- %
Reno-Sparks MSA	- %	- %	- %

### Headline Unemployment Rate

With respect to the unemployment rates the limitations of the model are more visible. However, the results still provide a reasonable look at the relative effects of the possible outcomes. While the No-Pandemic and Best-Case scenarios show extremely low unemployment rates of around % for Nevada, the Most Likely case shows that unemployment is expected to be about one to one and a half points higher. Figure The Worst-Case unemployment rates range between % for the Reno-Sparks MSA to % for the Las Vegas MSA.

### Nevada’s Unemployment Rate Varies Drastically Based upon the Scenario

Figure : Forecasted Nevada Unemployment Rate Source: RCG Economics  
Note: Data in parentheses represent the forecasted unemployment rate in Q4 1



### Unemployment Claims

Initial unemployment claims for Nevada in the Worst Case about are close to three times higher than in the Best Case about while the Most Likely case about is only

marginally worse than the Best Case. Relative to continuing claims, the results look fairly reasonable. The Best-Case estimates monthly average claims of around [redacted] while the Most Likely case is about three times higher, about [redacted]. Continuing claims for the Worst Case are about [redacted] times greater, about [redacted] than in the Best Case.

## The Impact of the Pandemic Will Likely Continue to Suppress Statewide Employment through the End of 2021

Table 4: Forecasted Change in Initial and Continuing Unemployment Claims in Q4 2020 Compared to Expected Claims Under No-Pandemic Scenario. Source: RCG Economics

	Best Case	Most Likely	Worst Case
Nevada Initial Unemployment Claims	+	+	+
Nevada Continuing Unemployment Claims	+	+	+

### Visitor Volume

Estimates show a significant hit to visitor volume in every scenario. The Best-Case scenario would be least impacted by the pandemic, experiencing a [redacted] % hit to visitation compared to the No-Pandemic scenario. The Most Likely scenario sees a drop of [redacted] % while the Worst Case suggests a [redacted] % drop. This is plausible considering that visitation dropped [redacted] % year-over-year in April during lockdown.

### Methodology

In this section, medical and economic background information about COVID-19 is discussed. Certain biological traits of this virus directly affect the inputs of the economic analysis herein and are therefore important to be discussed in some detail.

### Novel Coronavirus and Economic Shutdown

On December 31, 2019, Chinese authorities informed the World Health Organization (WHO) of an outbreak of pneumonia of unknown origin in Wuhan, Hubei Province. In March 2020, the WHO concluded that the rapidity and breadth of the spread of this disease constituted a global pandemic. This disease is named COVID-19 based on established naming conventions. It is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), a novel coronavirus. As of July 2020, it appears that a newer, more virulent strain of SARS-CoV-2 has replaced the original virus and become the dominant strain circulating around the world.

Following the WHO's declaration of the pandemic, as well as the closure of several school districts across the country in the preceding days, the economic dominos immediately started falling. The result was an economic downturn without precedent in modern times.

In the United States, the private sector initiated a series of events that quickly escalated into state-level shutdown orders. States all over the country began shutting down non-essential businesses. On March 23, California became the first to issue a statewide shutdown order.

In Nevada, on March 22—a day before the WHO's declaration—MGM Resorts International (MGM) announced that it would be shutting down their Strip buffets within days. A few days later, on March 25, MGM also announced that it would be shutting down all of its Las Vegas properties on

March On March Nevada Governor Steve Sisolak announced the closure of all non-essential businesses including hotel-casino resorts The Governor extended these closures and issued a stay-at-home order on April

A timeline of major governmental declarations relevant to Nevada COVID- policy according to the Nevada Independent and Nevada Health Response as well as other sources where noted is provided in the appendix

### **Information on SARS-CoV-2**

There is building evidence that COVID- may be a vascular disease with respiratory symptoms rather than a respiratory disease This helps explain why the disease can cause widespread blood clotting as well as damage in other parts of the body

According to the U S Centers for Disease Control and Prevention CDC the virus is mainly spread via the exchange of contaminated respiratory droplets in close quarters Furthermore the WHO has stated that the virus appears to be airborne meaning that it can linger in small droplets over long periods and still infect people Additionally Dr Roger Shapiro of the CDC and Harvard T H Chan School of Public Health said that the virus is easier to spread indoors than outdoors

Infections appear to be driven by people showing mild unnoticed symptoms which include the majority of those infected Additionally they may be contagious prior to showing symptoms One major means of virus spread appears to be through “super-spreader events ” According to Scientific American “between and % of infected people are responsible for % of the coronavirus’s spread ”

Mortality rates published thus far compare deaths to confirmed cases but this does not produce precise measurements of real mortality rates because it is unknown how many people have actually been infected as most cases are mild and do not require medical attention However it is clear that older people are at a vastly higher risk of death than younger people The CDC reported that out of deaths related to COVID- occur in people aged years and older Additionally the CDC has also found that the rate of hospitalizations of those aged + is more than times greater than for the least hospitalized age group - to -year-olds

It is possible that recovery from COVID- only confers partial immunity or no immunity at all meaning that someone can be re-infected with the disease after some period Additionally there may be life-long complications from secondary effects of COVID- These possibilities have helped stoke fears regarding the virus even given the apparent relatively low mortality rate

Despite the low fatality risks it is important to note that the coronavirus is still dangerous especially to older people in part because we know so little about it What we do know however is that the COVID- pandemic is already the fourth deadliest event in U S history compared to wars and previous pandemics

These fears at an individual level can be understood by a well-known branch of economic theory “Cumulative prospect theory ” predicts that people tend to overweight probabilities associated with unlikely negative outcomes As a result many people who face a small risk of death from COVID- assign a greater subjective assessment of their health risk The same theory is applicable to financial risks as well which helps to explain some of the backlash to the state-level shutdown orders

*Exaggerated fears of the risk to an individual's health especially if generally shared across the country will weigh heavily on the economy until widespread effective vaccinations have occurred*

## Mitigating the Outbreak

### Government Strategies

The main goal of government policies thus far appears to be reducing or eliminating the spread of COVID-19 through public policy interventions until the availability of a safe and effective vaccine. However, whether the state can attain this goal is questionable.

For example, contact tracing is a form of surveillance likely to face resistance in adoption. There are several methods of accomplishing this, but technology-based methods require residents to install an application on their phones. The app tracks all those who have come near another person with the app installed. When someone tests positive for a disease, the contact tracing app notifies any individual that came into proximity to that person. Ideally, persons notified will practice heightened social distancing for some time and get tested for the disease. However, contact tracing must be adopted by about 80% of a population to be effective. As of mid-April, the most-used contact tracing app is in Iceland and even they had only achieved a 60% adoption rate. Additionally, the success of such a program relies on quick and accurate viral testing, which is not yet available.

Policies of this kind will not be widely enacted before widespread vaccination becomes available. For this reason, RCG will assume that mitigation policies will have a very limited impact.

### Individual Actions

Despite the difficulties in mitigating the effects of the virus on the economy, reducing the spread of the virus may be enabled by the widespread use of masks. Recent studies suggest that there is likely a connection between widespread use of masks and lower levels of virus spread.

YouGov polling has found that countries with high rates of mask adoption generally are correlated with lower levels of spread. In Asia, China, India, and Singapore all have mask adoption rates of over 90%, as do France, Italy, and Spain in Europe. Germany is slightly behind at over 80%.

Unfortunately, wearing masks has become politicized in the United States. Nevertheless, there may be change coming. President-elect Biden will encourage the wearing of masks for 90 days following his inauguration.

## Current State of the Pandemic

The major determinants regarding the future economic situation in the United States and Nevada in the wake of the pandemic are COVID-19 case load and deaths. Comparing the most recent data on infections and deaths across nations, states, and over time within the United States and Nevada

better informs the assumptions within the model. This report offers used in the model that describe the Best-Case, Most Likely, and Worst-Case outcomes relative to the Nevada economy.

### **COVID-19 Statistics**

In this section, various statistics concerning COVID-19 are analyzed, comparing the United States to other nations as well as comparing Nevada to other states. A timeline of pandemic-related interventions and milestones can be found in Appendix B. A discussion of the pandemic's implications for Nevada's state and local economies within the model can be found in Appendix F.

Among all countries, the United States is ranked eighth in cases per 100,000 as of August 2020. This is made worse when considering that five out of the top 10 nations are essentially high-density city-states, such as Qatar, Bahrain, and San Marino. Since then, the virus has spread quickly and largely unimpeded.

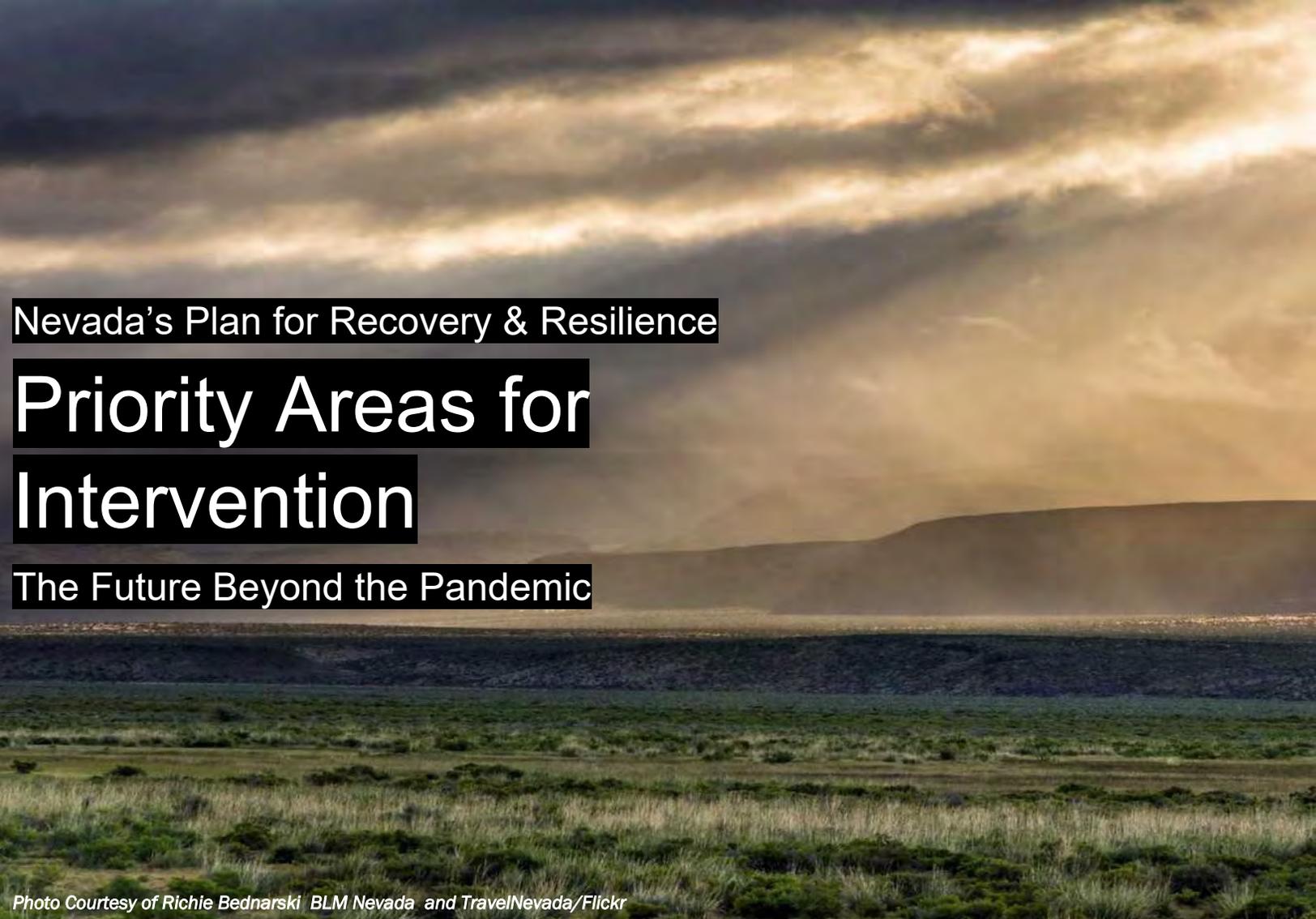
The United States also leads the world in total deaths. In terms of deaths per 100,000 persons, the United States was 10<sup>th</sup> globally. At the end of August 2020, among high-population countries, the United States had the fourth highest death toll per 100,000 in the world, 100 deaths per 100,000. This rate compared poorly relative to countries like Germany (20 deaths per 100,000), Japan (10 deaths per 100,000), and South Korea (10 deaths per 100,000), one of the first countries hit by COVID-19. By any measure, the United States has done a poor job responding to the pandemic compared to other nations, and it has negatively affected the economy, according to officials at the Federal Reserve.

At the state-level, relative to case load, Nevada appears to be middle-of-the-pack. However, as a state with a moderately-sized population, that does not convey much information. The states are better compared per 100,000 persons. In this case, caseloads in Nevada appear to be among the fastest growing, and Nevada is one of the worst-performing states overall as well. As of August 2020, Nevada sits at ninth out of 50, including Washington D.C. and Puerto Rico.

Regarding COVID-19-related deaths, at the end of August 2020, Nevada was 10<sup>th</sup> out of 50 states and territories in terms of deaths per 100,000, just in the upper half of the rankings. The country's hardest hit region has been the Northeast. New Jersey and New York are the hardest hit states with Massachusetts and Connecticut ranking third and fourth. The first state outside of this region, Louisiana, was fifth.

Generally, the data relative to the United States and Nevada indicate that as of August 2020, the United States is doing a poor job of containing the pandemic compared to other countries, while at the state-level, Nevada is doing a mediocre job of containing the virus compared to other states. However, luckily, despite the high rate of spread of the disease, Nevada has been thus far spared from a relatively high death toll.

Additionally, there has been some evidence that people have been heeding mitigation advice. One study showed that infection rates fell dramatically after an initial surge in regions all over the world.



Nevada's Plan for Recovery & Resilience

# Priority Areas for Intervention

The Future Beyond the Pandemic

*Photo Courtesy of Richie Bednarski BLM Nevada and TravelNevada/Flickr*

## Priority Areas for Intervention

The COVID-19 pandemic and its effect on Nevada's economy has required swift action by GOED and supporting organizations and agencies. At a high level, GOED has focused its interventions within five broad priority areas, which can be found below. Importantly, GOED's response to the pandemic does not occur within a vacuum. Other state agencies, such as the Department of Business and Industry, and local government organizations, provide support within these functional areas and, in some instances, lead their own interventions where relevant.



## Resources for People and Businesses

*Modernize Nevada’s financial technological and administrative capabilities*

**Immediate recovery:** GOED must actively support any Nevada agency that is part of the flow down of federal funds. It will be necessary for all businesses—especially small- and medium-sized enterprises (SMEs)—to receive guidance and advocacy assistance to secure the funding they need to keep employees on the roster. Capacity has been increased at the state’s career centers to help process individuals’ unemployment claims. Gig workers and other independent contractors—a significant population in Southern Nevada—who can participate in programs that can be confusing. Direct support for SMEs through federal loan programs is also critical—an important lever for reducing the unequal economic impact of the crisis.

**Longer-term resilience:** % of Nevadans are unbanked or underbanked according to a FDIC report. Without a bank account, it is difficult for individuals to receive stimulus checks and other government assistance. In the medium term, there is a role for public action to build an appropriate financial infrastructure for workers that will help shelter them from future shocks. This could take a variety of forms, including a one-stop public assistance program with digital accounts and mobile payments. TANF, WIC, unemployment payments, and other benefits could be integrated into one system. Success in this area is contingent on success with initiatives targeting connectivity and the digital divide, addressed below.

Specific areas of interest for GOED and supporting organizations could include:

Update and integrate all state administrative and financial systems including payment systems to residents such as UI TANF WIC Medicaid etc see below for longer-term initiatives in this policy area

Build a community banking network Community banks were essential to the success of the PPP program Community banks with billion or less in assets made about percent of the overall number and value of PPP loans

Employ a “Buy Nevada” tactic in which local purchases are steered toward local firms when possible

## Business Support and Expansion

*Increase support for entrepreneurship and micro- small- and medium-sized enterprises MSMEs and investment in new technology applications Review of target sectors onshoring foreign investment attraction and export opportunities*

**Immediate recovery:** While large corporate enterprises can develop protocols for operating within the context of the new normal main street businesses MSMEs will need guidance on the protocols and practices required to operate under these new conditions They will need guidance on how to use open spaces enforce social distancing and expand onsite sanitary capabilities This guidance will be accompanied by onsite training of incumbent workers

**Longer-term resilience:** GOED should take deliberate steps to attract greater levels of foreign direct investment to Nevada while supporting the emergence of export-oriented industries throughout the state International trade and foreign direct investments drive Nevada’s competitiveness contribute to productivity growth create jobs and exports support R&D activities and fuel innovation International companies broaden the state’s economy and make it more resilient adding prosperity to workers and communities and investing in workforce training solutions across the state

Specific areas of interest for GOED and supporting organizations could include:

Open business recovery centers within the network of Nevada’s Small Business Development Centers See the next section regarding new institutional arrangements in support of small business

Increase funding for technology-based entrepreneurship and provide targeted support for technology-based firms in automation and digital technologies

Develop an ecosystem that enables more entrepreneurship commercialization and new business creation with renewed focus on digital arts and outdoor recreation

Promote international trade and export assistance programs to increase the number of exporters new market exports and global supply penetration especially among rural and women- veteran- and minority-owned MSMEs

Identify gaps in support for minority- and woman-owned small businesses and opportunities to increase their establishment and growth

Increase efforts to attract U S and foreign businesses to Nevada particularly those in high-growth and technology-intensive industries

Streamline and centralize the oversight of Nevada’s small businesses with clear direction for ancillary support organizations in preserving establishing and expanding Nevada’s businesses

## Workforce for the New Normal and Beyond

*Full implementation and expansion of existing workforce initiatives*

**Immediate recovery:** GOED should play a leadership role in the transformation of occupational licensing constraints in critical areas including the recognition of qualifications from other states Based on real-time labor market data GOED will support community colleges in recruiting and graduating students in areas of need In spite of the general downturn there will be sectors experiencing high demand that will need newly trained workers including sectors beyond health services

**Longer-term resilience:** In order to accelerate workforce adjustment and preparation in critical areas GOED should support the design of compressed health services curricula and other curricula for skills in short supply The entire workforce pipeline should be reworked so that workers from hospitality can be fed into public health and other needed fields with an emphasis on competencies and skills rather than formal credentials

Specific areas of interest for GOED and supporting organizations could include:

Radically expand health services programs at all levels

Integrate workforce programs with business needs

Allow community colleges to develop accelerated training programs for employers continuing or resuming operations

Broaden training providers to reach disadvantaged populations and apply new technologies through the Nevada State Library by leveraging Nevada’s Education Stabilization Fund-Reimagine Workforce Preparation ESF-RWP grant

Protect funding streams for in-demand and growing occupations’ academic programs at Nevada’s four-year institutions

Accelerate the use of “badges ” competence bundling and credit aggregation in building workforce skills

Provide incentives to U S citizens who work remotely to relocate to Nevada as well as for startup founders doing all or most of their business online

## New Technology Businesses

*Review and redesign Nevada’s approach to retention and business development that provides wrap-around support to technology adoption by MSMEs*

**Immediate recovery:** The state will identify the most appropriate technologies and formulate plans for deployment at an extraordinary scale by state and local government. It will provide guidance to Nevada businesses looking for reliable information on useful technologies.

**Longer-term resilience:** If Nevada succeeds in mobilizing technologies at scale, it will have laid the groundwork for repositioning the state in the national and world marketplace. Consumers may be reluctant to travel at present, but the desire for recreation will endure. Nevada can be the recreational haven of the future, fortified by best-in-class measures in public health. Nevada’s regional economic development authorities will continue to recruit companies to Nevada to strengthen the healthcare system.

Specific areas of interest for GOED and supporting organizations could include:

Support the development of websites and e-commerce capabilities for MSMEs to expand opportunities for business-to-business and business-to-consumer e-commerce transactions

Aggregate and share vendor information for contactless and online payment systems

Support the increased use of sensors and other technologies for security and safety

Introduce and promote new digital instruments to enable exporting by Nevada’s MSMEs

Foster connections and collaboration with local and international stakeholders to prioritize balanced long-term growth and sustainable economic development

## Data and Integrated Planning for Decision-Making

*Nevada must complete the transition to smart government at the state and local level*

**Immediate recovery:** Any decisions made on reopening Nevada’s economy must be based on all available data and as part of integrated state-wide plans. Coordination, collection, and sharing data is a critical role for GOED. In particular, GOED will be responsible for integrating public health data with economic data and proposed infrastructure initiatives within a single state framework. This will enable GOED to provide reliable advice to Nevada’s businesses and workforce institutions.

**Longer-term resilience:** Confidence in Nevada’s future economy will depend more than ever on complete, transparent information that integrates public health, economic, and workforce data. GOED will own this responsibility and become the one-stop data hub for the state with an emphasis on the credible communication of information regarding the health of the state’s economy and

society In addition GOED will give the Regional Development Authorities RDA access to data from EMSI see the bullet below

Specific areas of interest for GOED and supporting organizations could include:

-----  
Integrate regional infrastructure initiatives within overall state financial and planning framework  
-----

-----  
Provide access to real-time labor market Information using EMSI data via Nevada's regional development authorities  
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Nevada's Plan for Recovery & Resilience

# Visionary Strategies for a Changing State

The Future Beyond the Pandemic

*Photo Courtesy of Kurt Kuznicki and BLM Nevada/Flickr*

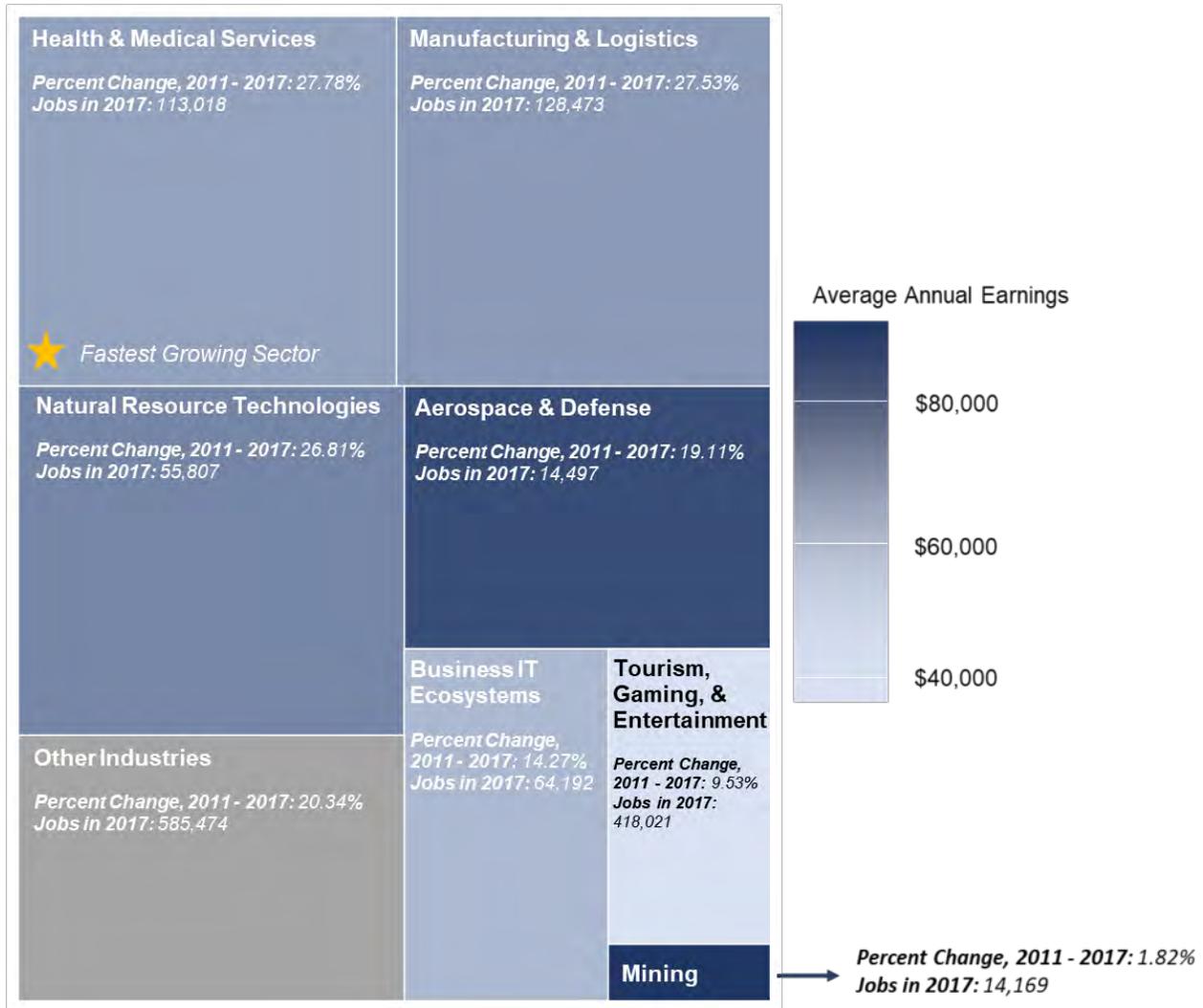
## Nevada at the Crossroads

As the immediate actions contained in the recovery and resilience plan are implemented state leaders must turn their attention to strategic initiatives that ensure Nevada's economic and social resilience into the future. Whatever the timeline for recovery, both in public health and in the economy, Nevada must immediately begin pursuit of these strategies. Only in this way can the state ensure a complete recovery and shape its future growth toward a more resilient and high-value future.

Once again, the state is at a crossroads, especially Southern Nevada. After the Great Recession, new industries grew more quickly in the North and the South than the legacy sectors.

## Nevada’s Economy Has Seen Considerable Growth in New and Emerging Industries

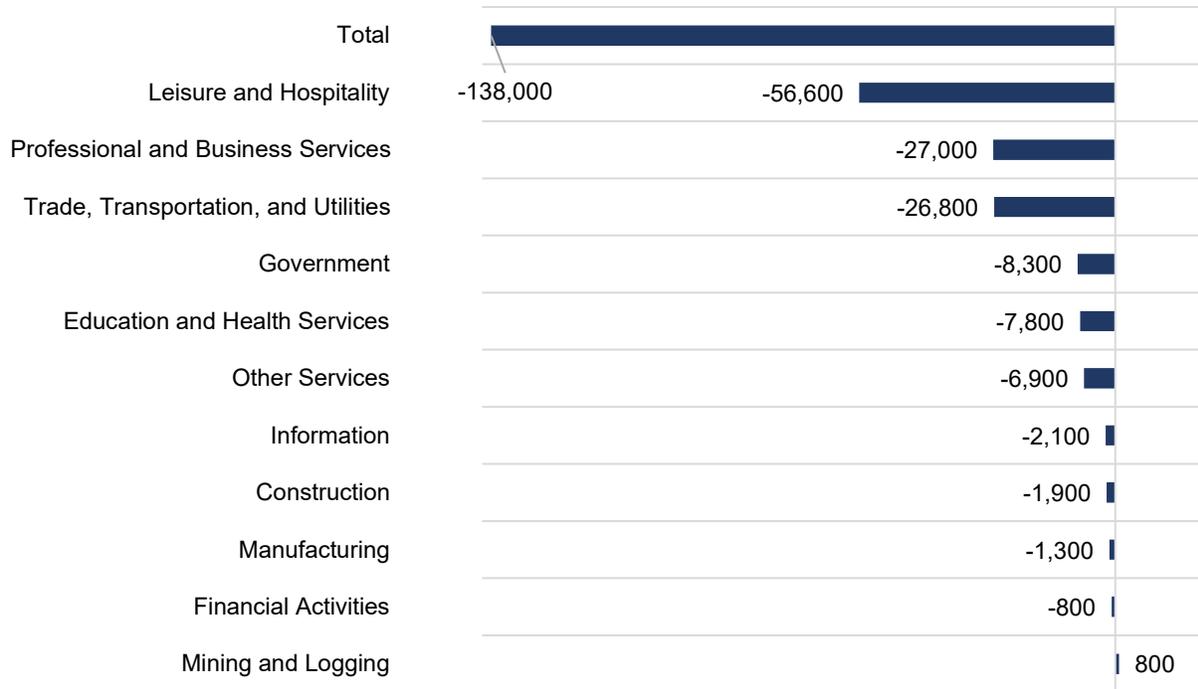
Figure 3: The Changing Industries of Nevada's Economy 11 to 17 Source: EMSI and GOED



But diversification takes time. The two sidebars below discussing the changing economies of urban and rural Nevada demonstrate the progress that has been made in Northern, Southern, and rural Nevada. While Northern and rural Nevada are beginning to show signs of well-diversified regional economies, Southern Nevada began from a small base, and the present crisis came too soon for the benefits of any nascent diversification to be properly felt. These changes are not negated by the crisis but rather accelerated by it. As Figure 3 below indicates, advanced manufacturing, logistics, health services, clean tech, and information technology proved to be resilient when the downturn came and will be the foundation for the future. The strategies outlined below will underpin growth in these areas. This section is followed by a section on the imperative for building and modernizing the institutions and capabilities that will be necessary to secure the future of the state for the long run.

## Statewide Job Loss Remains Concentrated in Nevada’s Service Industries

Figure 4: Nevada Job Change by Industry July 19 to July



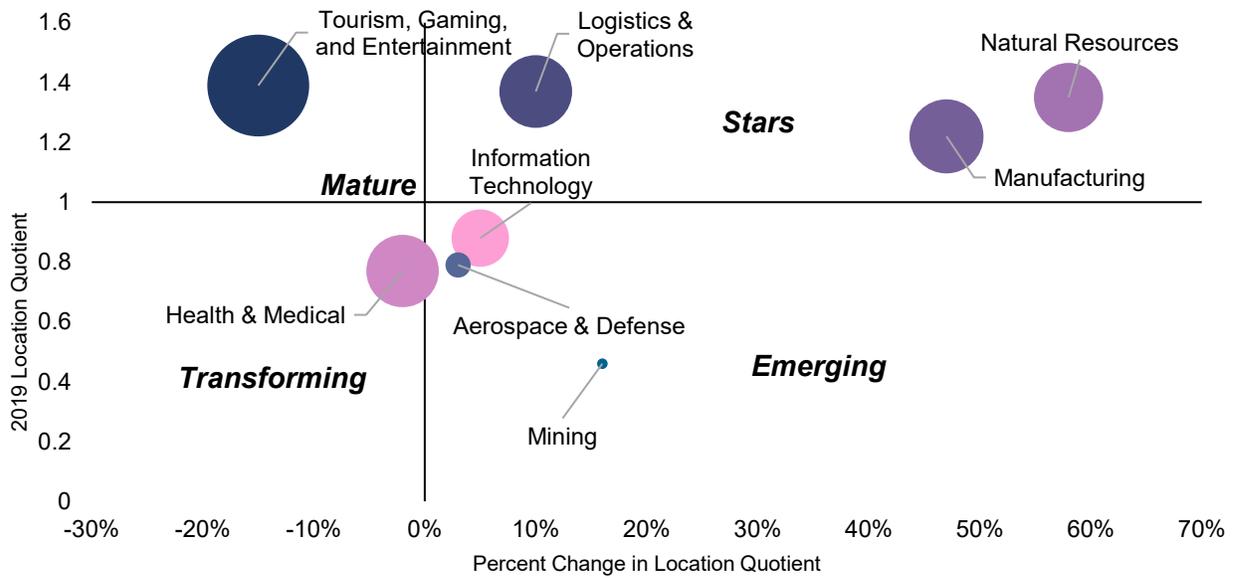
### Urban Nevada

Figure and Figure below visualize the location quotient for selected industries and how they have changed between and in Northern and Southern Nevada respectively. As shown, Northern Nevada has seen greater growth in new sectors, particularly Manufacturing and Logistics & Operations, that have worked to diversify the region’s economy. In Southern Nevada, however, Tourism & Gaming continues to dominate the region’s economy. While other sectors have grown over the last decade, they have yet to grow to resemble a significant portion of Southern Nevada’s economy. This is likely a critical component of the comparatively lower impact of the pandemic recession in Northern Nevada than in Southern Nevada. However, the large number of industries that fall into the “emerging” category demonstrate that the region shows promise for future diversification efforts.

*Location Quotients (LQ) allow an area's distribution of employment by industry ownership and size to be compared to the national average. If an LQ is equal to 1, then the industry has the same share of its area employment as it does in the nation. An LQ greater than 1 indicates an industry with a greater share of the local area employment than is the case nationwide. For example, Las Vegas will have an LQ greater than 1 in the Leisure and Hospitality industry because this industry makes up a larger share of the Las Vegas employment total than it does for the nation as a whole.*

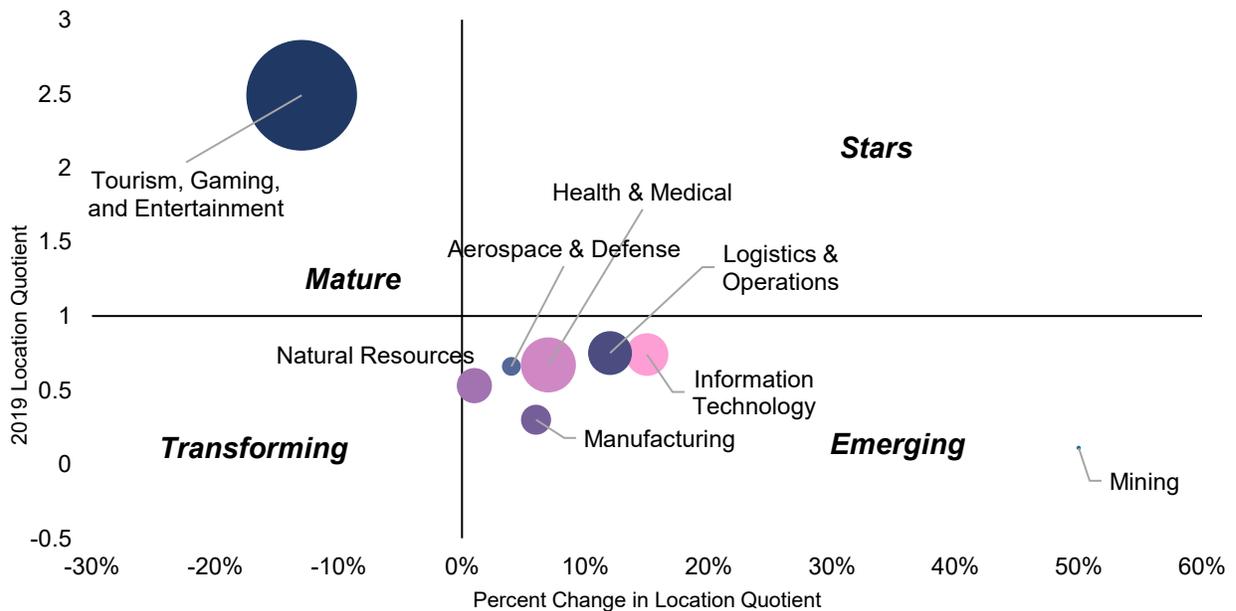
### Northern Nevada Has Been Comparatively Successful at Growing New Industries

Figure 5: Percent Change in Location Quotient for Selected Industries in Northern Nevada 1 to 19 Source: GOED



### Southern Nevada Has Seen New Industries Emerge, but Diversification Remains Nascent

Figure 6: Percent Change in Location Quotient for Selected Industries in Southern Nevada 1 to 19 Source: GOED

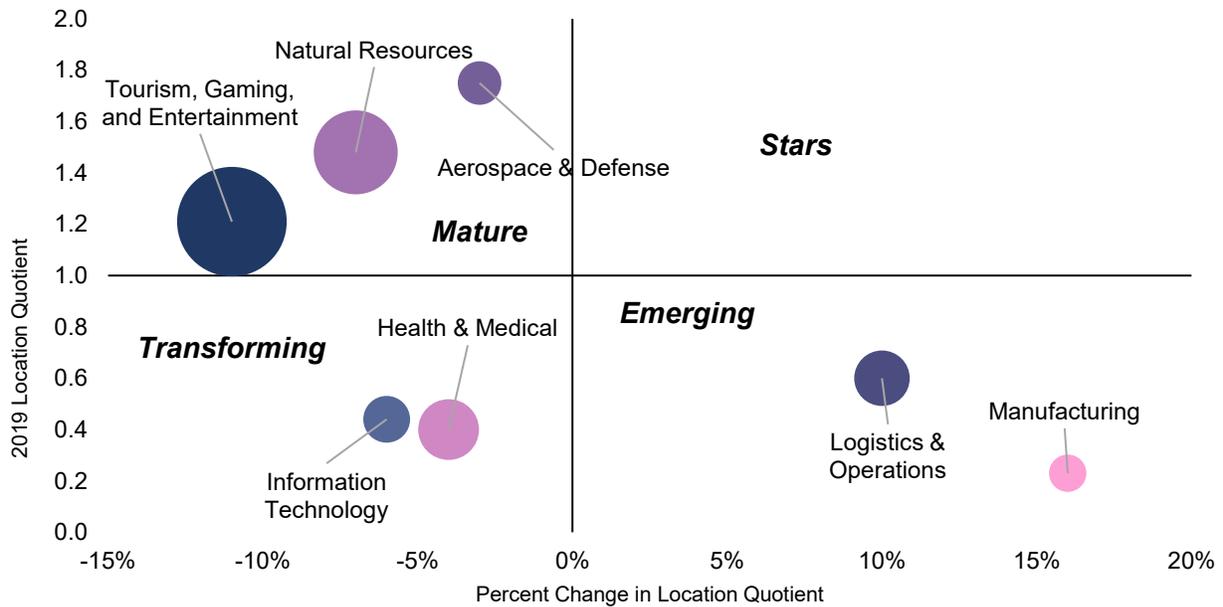


## Rural Nevada

Figure and Figure below provide an overview of the industries that comprise rural Nevada's economy. As shown, rural Nevada's economy is notably more diverse than Southern Nevada's economy, though it does remain dependent on industries that typically respond aggressively to economic shocks, particularly Tourism, Gaming, and Entertainment and Natural Resources. However, more stable industries, such as Logistics & Operations and Manufacturing, have begun emerging in the rural economy, providing greater and more consistent employment opportunities to those with post-high school training but perhaps less than a traditional four-year degree. Figure however, shows just how much the mining industry has grown in rural Nevada. While the location quotient for most of rural Nevada's industries range from to the region's mining industry faces a location quotient of over far outweighing the location quotient of industries that have traditionally dominated Nevada's economy, such as Tourism, Gaming, and Entertainment, which has a location quotient of just in rural Nevada.

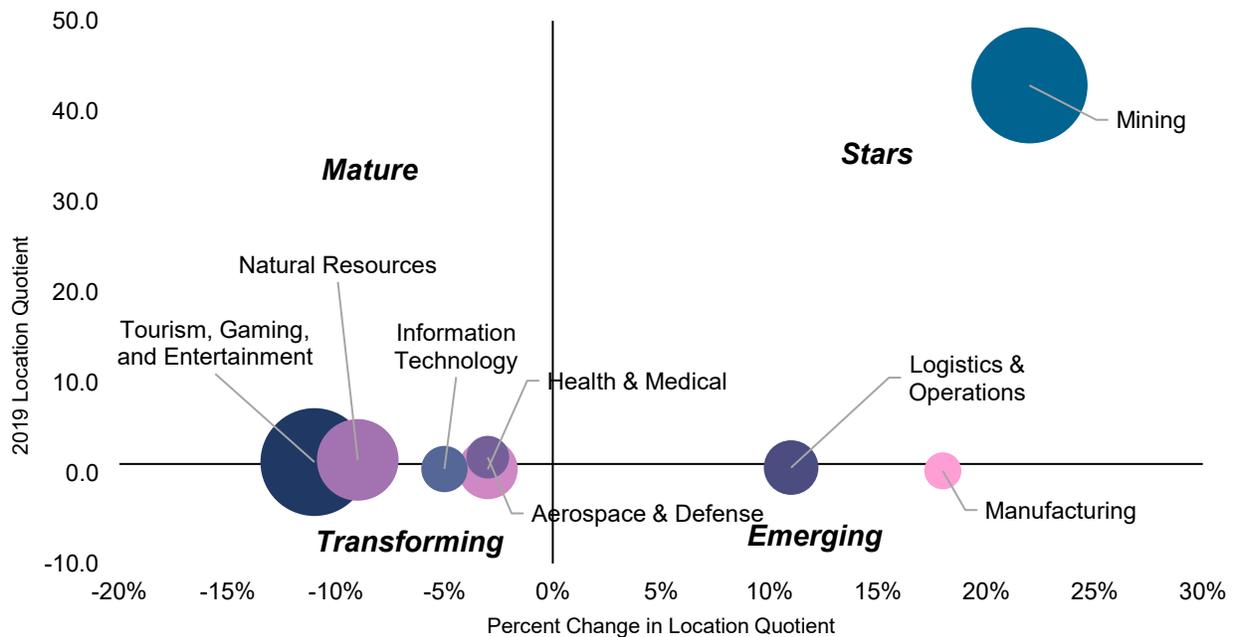
## A Healthy Mix of Industries Form Rural Nevada's Economy

Figure 7: Percent Change in Location Quotient for Selected Industries in Rural Nevada Excluding Mining 1 to 19  
Source: GOED



## For Rural Nevada, Mining Has Become an Undeniable Engine in the Regional Economy

Figure 8: Percent Change in Location Quotient for Selected Industries in Rural Nevada Including Mining 1 to 19  
Source: GOED



### Nevada’s New Economic Geography: The “Three Nevadas”

Nevada is geographically well-situated between three vibrant economic partners: California, Arizona, and Utah. Each of these states exchanges people, goods, and ideas with Nevada. Despite having a population of just over 3 million, Nevada sits at the center of a trade region that exceeds 100 million residents—a region that exceeds in both population and GDP such nations as South Korea (pop. 50 million) and Spain (pop. 45 million).

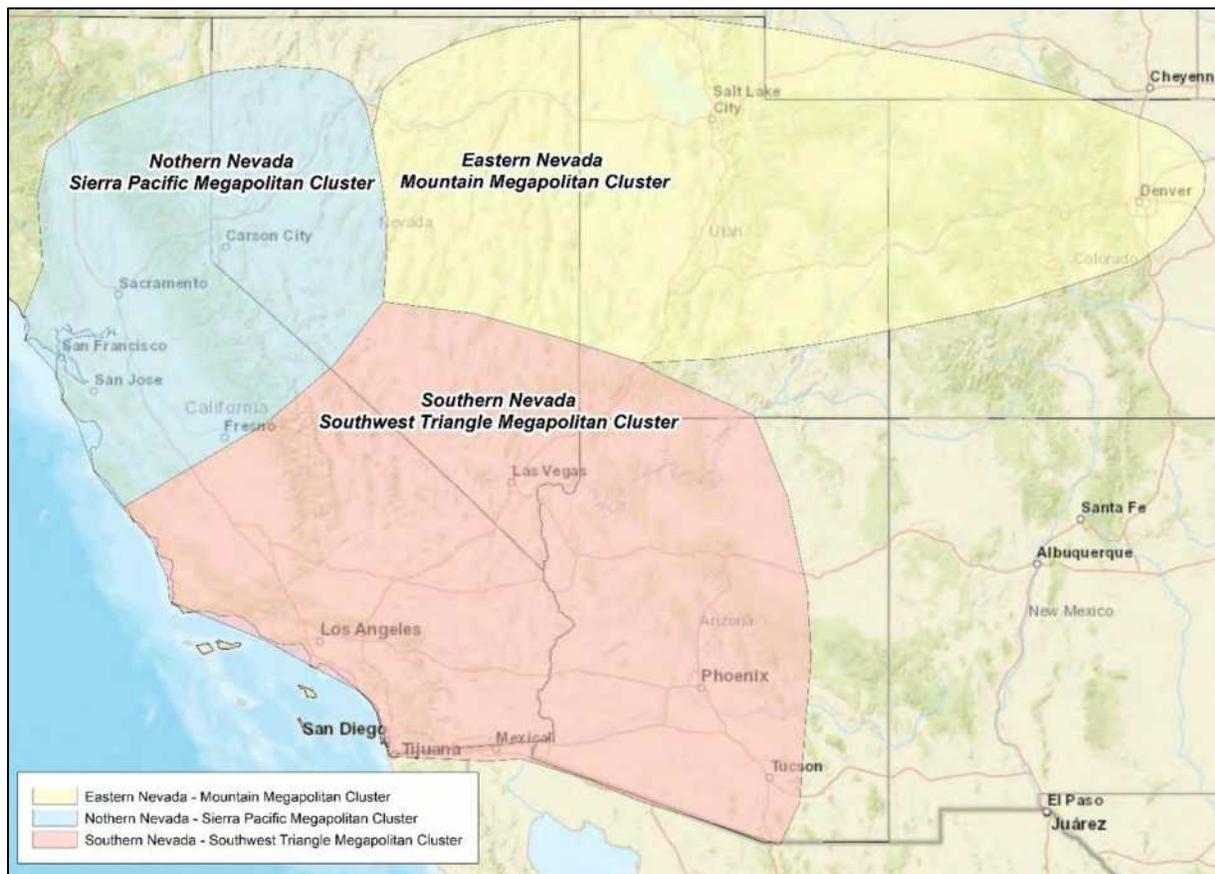
According to the U.S. Census Bureau, Nevada’s two largest metropolitan areas—Las Vegas MSA (pop. 2.2 million) and Reno-Sparks MSA (pop. 1.1 million)—join in the two largest urban complexes, or “megapolitan areas”<sup>46</sup> in the western half of the United States. Las Vegas is part of the “Southwest Triangle megapolitan cluster,” which includes Southern California and Arizona’s “Sun Corridor” megapolitan area (Phoenix and Tucson)<sup>47</sup>. Together, these regions now contain about 100 million people and form the second most populous megapolitan cluster behind the “Northeast Megalopolis.” Reno lies at the eastern edge of the Sierra-Pacific megapolitan area, which includes the Bay Area and Sacramento metros. The Sierra-Pacific region includes about 100 million residents.

Likewise, Elko, a micropolitan area with 100,000 residents in 2010, maintains extensive economic and trade relations with megapolitan areas in the Mountain West. Elko and much of eastern Nevada connect to the “Wasatch Range” (Salt Lake City) and “Front Range” (Denver) megapolitan areas. By 2010, the regions together contained over seven million residents. Nevada is privileged in that its logistics, tourism, technology, and resources industries are embedded in the western United States—a geographically broad but extensively urbanized and fast-growing region that maintains some of the most innovative and export-driven regional economies in the developed world.

Figure below shows what Brookings Mountain West at UNLV terms “The Three Nevadas ” The three zones identified show the approximate area of economic interdependence that links Nevada to California Arizona and Utah Las Vegas falls within a sphere that extends from California’s Central Coast to the Mexican border with Arizona Reno’s economic sphere incorporates much of Northern California Elko’s shared economic space stretches across Utah to Colorado’s Front Range

**Each of Nevada’s Regions Remains Well-Positioned to Megapolitan Areas Throughout the Western United States**

Figure 9: Nevada's Megapolitan Clusters Source: Robert E. Lang and Jaewon Lim Brookings Mountain West--UNLV



These megapolitan areas exhibit an economic integration either approaching or equal to what the U.S. Census Bureau defines as “combined statistical areas” or CSAs. Being a CSA is significant in that it shows urban space has achieved high levels of economic integration centered on commuting patterns. Nevada is becoming more connected with its neighboring states via a myriad of economic functions. Tech transfers from the Bay Area to metro Reno have transformed Northern Nevada. Las Vegas shares a wide array of trade, patents, highway, air links, and now direct labor markets with California and Arizona. Gold mined in central Nevada is processed in Utah and often managed from Colorado. Nevada’s most important economic opportunities lie in deepening its ties to adjacent megapolitan areas. The state can induce both corporate relocation and skilled labor migration from the greater Southwest. Nevada maintains lower costs, less regulation, and less tax burden, especially when compared to California.

Even before the pandemic technology allowed an increasing share of workers to live in one region while performing jobs in other metropolitan areas. Distance commuting beginning in many tech and sales sectors made megapolitan geography possible. Flexible workspaces where an employee needs to physically be present at a common job location once a week or even once a month allowed workers to commute from 100 or more miles away from their actual office. This is especially true for many gig-economy jobs in tech, media, and R&D-intensive sectors.

Nevada, linking to and lying between the largest megapolitan areas in the West, is well positioned to benefit from an explosion in distance commuting as virtual workspaces become the norm following COVID-19. Consider that a tech worker in Silicon Valley can now live at Lake Tahoe and still check in at the “office” every day. Perhaps such a worker needs to attend a sales or all-staff meeting every few weeks and thus cannot simply move to Alaska or Hawaii. Northern Nevada is a lower cost, less congested alternative to the Bay Area, but maintains highway and air connections back to California so that one can physically be present in San Jose or San Francisco on any given day.

Given Nevada’s urban geography, which connects the state to large-scale metropolitan systems in California and Arizona, surface transportation improvements between Las Vegas and Reno have a lower priority from the point of view of the workforce. The value from improving this connection is related to the completion of an integrated logistics network across the region, which will involve rail links rather than road and/or air; the complete rail right-of-way is still available. When it comes to the workforce, Nevada must double down on accessing California and Arizona, and in the case of Elko, the Mountain West and Northwest Megapolitan areas.

## Visionary Strategies

Strategic initiatives to ensure medium-term prosperity have been organized into the following five categories and are discussed in the relevant sections below:

- Regionally Designed Industrial Clusters
- Statewide Integration and Connectivity
- Technology-Driven Development
- Responsible and Sustainable Growth
- Comprehensive Placemaking

### Regionally Designed Industrial Clusters

The impact of the Great Recession on Nevada’s economy alerted state policymakers to the need for economic diversification. Prior to the economic crisis, Nevada’s primary urban areas may have been classified as “company towns” where local economies were overdependent upon a few employers in a single industry for economic growth. The policy response following the Great Recession called for a state-led pursuance of key industries on which Nevada could capitalize for new, stable growth. Growth in new and emerging industries has been notable, with advanced manufacturing, transportation and logistics, and healthcare emerging as strong contenders in Nevada’s economy.

The economic crisis spurred by the COVID-19 pandemic has once again drawn attention to the need for economic diversification. Developments in the world economy, such as the push for more localized production and value chains, represent opportunities for Nevada. Businesses will push for proximate, smart supplier networks. Given its close location to the West Coast, this new imperative

will drive new investment toward the state. This investment will tend to be technology- and skill-intensive, paying good wages to a properly prepared workforce.

In order to make the most of these opportunities and build on Nevada's unique geographical advantages, the recommendations below include a variety of necessary infrastructure investments. None can be done in a day or in a week, but even ambitious infrastructure programs will help the state quickly recover from the crisis, as well as lay the foundations for a new, resilient economy in the future. The impact of this crisis will be felt for many months, perhaps several years. Furthermore, there will be no return to the world as it was in February. Business travel and business meetings are now based on a wholly new technological infrastructure. Consumers' attitudes regarding entertainment and recreation have undergone a significant shift. The structure of the workplace has changed forever for millions of white-collar workers.

### **Design New Approaches to Cluster Identification and Development**

Economic diversification has evolved differently in Nevada's various regions. In Northern Nevada, gaming, tourism, and hospitality gave way more completely to new industries following the Great Recession, particularly advanced manufacturing. In Southern Nevada, the dominance of the leisure sector is more pronounced, but the local economy has seen the emergence of data centers and logistics and transportation as promising avenues for future growth, among others. This growth will be accelerated by the present crisis. Southern Nevada is at the same fork in the road faced by Northern Nevada ten years ago. Its future will remain distinctive, and the legacy sectors of hospitality and entertainment will remain strong—Vegas will remain Vegas. But the region needs accelerated growth in other areas—including health services, logistics, and clean tech—alongside this world-class entertainment cluster if the region is to be diverse, prosperous, and resilient in the future.

The capabilities of Nevada's regional development authorities (RDAs) have been made clear in recent years and represent a valuable resource for future diversification efforts. As RDA staff are embedded in their local communities, RDAs are well-positioned to identify and pursue promising industries for their respective regional economies. There remains a role for GOED to ensure the RDAs pursue a unified approach to diversification and that competing priorities are minimized. Likewise, at the state level, attention should be focused on integrating regional cluster strategies with a high-level economic diversification strategic plan that enables Nevada's regions to establish, grow, and mature industries that diversify the state's economy.

Specific areas of interest include:

- **Develop Regionally Specific Industry Plans** Enable RDAs to use their extensive knowledge of local capabilities to devise locally relevant clusters as part of a Comprehensive Economic Development Strategy (CEDS) that represent unique paths to economic success for each region.

### **Integrate into Regional and Global Value Chains**

The global economic crisis spurred by the COVID-19 pandemic has strained the production and distribution of critical goods. In the first several weeks of the pandemic, supplies of personal protective equipment (PPE) were very low, threatening the ability of front-line workers to address local outbreaks of the disease. While the private sector has mobilized to produce many of these necessities in the short-term, the disruption of supply chains has urged state and national governments to regionalize, rather than globalize, the production of many goods.

The “reshoring” of production to the United States presents Nevada with the opportunity to grow its nascent advanced manufacturing sector while integrating further into the regional economy of the western United States. The low cost of doing business in the state makes it an attractive destination for manufacturers who want to invest and produce in the United States and export globally but do not want to pay the typical cost of doing business on the West Coast. Likewise, Nevada remains an attractive destination for the “next-shoring” of the technology-intensive industries that comprise Industry. Nevada’s proximity to major urban areas with large consumer populations throughout the western United States increases its attractiveness for advanced and technology manufacturing.

Specific areas of interest include:

- **Fortify Nevada’s Small Business Community** Building job-creation capacity through entrepreneurship and SMEs by empowering them with the tools they need to restore trade and promote supply chain resiliency
- **Modernize Nevada’s Economy through Foreign Direct Investment** Attract foreign direct investment by building on existing international investors recruit foreign companies interested in key Nevada sectors
- **Globalize Nevada Businesses** Reinforcing state international trade programs to help local businesses start or expand their exports in the global marketplace
- **Export Nevada’s Knowledge Capital** Strengthening relations with foreign partners to develop platforms for sharing challenges and best practices across technology and innovation domains including water-tech, autonomous systems, advanced manufacturing, and logistics

### Enable Further Diversification of Southern Nevada’s Economy

Although the leisure and hospitality industry continue to be prominent throughout Southern Nevada, the region has successfully attracted new medium- and high-tech industries and sectors with potential for further development, notably logistics and advanced manufacturing. Future growth in these industries, however, is contingent upon the communities of Southern Nevada being able to meet the needs of employers in these industries. Considerable work continues to be done at the state and local level on workforce development, but there remains a need for further industry-specific infrastructure development throughout Southern Nevada.

*Meeting the needs of new industry clusters requires a suitable workforce and an enabling environment for going to scale*

Industries such as logistics and advanced manufacturing require medium- and large-scale infrastructure assets to establish a presence and grow. Developments like the APEX Industrial Park in northern Clark County have significantly expanded the region’s capacity for manufacturing and logistics, and at least one study found the industrial park capable of creating around 1,000 direct jobs and up to

1,000 induced jobs throughout Southern Nevada. However, the same report found that adequate infrastructure remains a challenge for growth at APEX, and the lack of integrated transport options for employees and goods limits the opportunities for additional industrial development at the site.

Aside from the APEX Industrial Park in northern Clark County, there remains opportunity for additional development in other areas of Southern Nevada, where logistics and advanced manufacturing may be developed concurrently and capitalized on for regional growth. Areas of southern Clark County have received increased levels of interest for numerous projects, including the proposed second airport for the Las Vegas metro area, a manufacturing and business park, and other mixed-use developments. The establishment of an advanced manufacturing park and smart

logistics hub in southern Clark County would contribute to the long-term vision for this area of Southern Nevada and position the region as a major producer and distributor of goods in the western United States

Specific areas of interest include:

- **Establish an Advanced Manufacturing and Logistics Hub** Promoting the creation of industrial clusters with innovation programs and intermodal logistics capabilities
- **Expand Air Passenger and Cargo Capabilities** Creating a major global trade and passenger hub in the inland Southwest
- **Grow Nevada's Professional Sports Industry** Strengthening Nevada's sports sector including professional teams' infrastructure sports medicine and healthcare; investing in sports tourism to drive employment and increase the "per capita" contribution of the sports sector in the state economy

## Statewide Integration and Connectivity

Nevada's geographic proximity to major western markets makes it a competitive destination for U S manufacturers Likewise the strong air connectivity between Reno-Sparks and Las Vegas and many domestic and international destinations has enabled the continued development of the state's leisure and hospitality industries However intrastate connectivity continues to be a challenge for Nevadan residents and businesses While Northern and Southern Nevada are well-connected to other urban markets throughout the West there remains a notable dearth of infrastructure between northern and Southern Nevada

The benefit of further infrastructure investment is twofold: increased rail and truck connectivity bolsters Nevada's opportunity to serve as a major transit hub for the western United States and the development of this infrastructure represents opportunities for short- medium- and long-term employment in construction and transportation industries Additionally increased roadway connections between northern and Southern Nevada provide a more affordable alternative for intrastate transportation to businesses and residents of these respective regions This means that there exist tremendous opportunities for employment today while making transformational infrastructure investments that will set Nevada on a new path in the future Further development of Nevada's infrastructure assets will support the emergence and growth of new industries

## Integrate and Expand Capabilities between Northern and Southern Nevada

With the help of GOED and federal policies Northern and Southern Nevada have successfully capitalized on their respective strengths to develop new industries and sectors such as Opportunity Zones However a continued lack of connectivity between Nevada's principal urban areas remains an obstacle for the state's economic diversification ambitions particularly the growth of the transportation and logistics industry Both regions have sought to develop this industry—as well as others that are dependent upon strong regional and national connections such as advanced manufacturing—independently rather than through a coordinated approach Likewise the missing connections between the northern and southern portions of the state have contributed to the "missing middle" of western Nevada where economic opportunity has remained a consistent barrier for many of the region's residents

Connecting northern and Southern Nevada with one another and the communities that lay between them is a necessity for the state's residents and businesses Much work has been conducted to identify opportunities for roadway expansion between Reno-Sparks and Las Vegas The

Intermountain West Corridor Study was completed in 2015 to outline the extension of Interstate I-15 from southern Las Vegas to Phoenix, Arizona, and subsequent proposals have been made to extend the I-15 corridor north to Reno-Sparks, connecting Nevada's two primary urban areas and connecting Las Vegas with I-80. Expansion of I-15 should be seen beyond passenger transportation but also as the major infrastructure investment in the emerging Southwest Triangle Megaregion (see Appendix A regarding Nevada's unique geographic advantages), which is on the trajectory to be one of the most economically strong American regions, but it is the only one without the interstate system between two of three major metropolitan areas: Las Vegas and Phoenix; major freight movement is going through Texas and California, omitting Las Vegas.

Aside from highway expansion, opportunity exists for development of rail lines, both freight and passenger, that connect northern and Southern Nevada, as well as the rural and frontier communities of western Nevada. Establishing multi-modal facilities in the Reno-Sparks and Las Vegas metro areas would provide anchors for future freight and passenger roadways and railways and create opportunities for industrial development in underserved western Nevada communities. In Northern Nevada, the creation of the Innovation Park at Tahoe-Reno Industrial Center, led by Blockchains LLC, represents an opportunity to centralize medium- and high-tech manufacturing in the Reno-Sparks area while increasing regional and national rail connectivity. This connectivity would allow the communities between Las Vegas and Reno-Sparks to participate in the development of Nevada's western frontier.

Specific areas of interest include:

- **Develop the Fernley Multi-Modal Hub** Expanding manufacturing and logistics opportunities for Northern Nevada and intra-state connectivity
- **Establish Logistics and Manufacturing Parks in Northern and Southern Nevada** Supporting the development of competitive manufacturing and logistics industries throughout the state

**Expand Broadband Accessibility**

Access to high-speed, reliable broadband internet service is required for the “digital prosperity” of our economy, educational systems, healthcare services, and state and local governments. Nevada's leaders face an enormous challenge. Too few people and communities have access to quality broadband technology: “If broadband is essential infrastructure, then regulation and public policy should support every American community having equitable access to broadband and the skills necessary to use it.”

For rural communities, broadband may be the only viable solution to the delivery of healthcare and educational services. For instance, Pennsylvania launched a broadband initiative with a focus on rural communities, with Governor Wolf noting: “The critical need for high-speed Internet has become clear in light of our efforts to mitigate the spread of COVID-19, as more families work and learn from home, businesses operate online services, and patients access medical care through telehealth.”

Broadband access often varies by income, race, and remoteness. In the case of Nevada, the “Las Vegas-Henderson-Paradise MSA” has the highest rank of broadband access in the Mountain West. However, 15% of the area's population maintain low broadband subscription rates. Access in the state's rural communities remains limited by the physical absence of the networks needed to support broadband.

Access to broadband is essential to remote education and distance learning. School leaders and elected officials are searching for resources to provide broadband access to those who need it. Even

in the state's most urbanized county the Clark County School District (CCSD) estimates that as many as 15% of students require assistance to gain adequate internet services

To help address these challenges, Attorney General Aaron Ford recently announced the launch of T-Mobile's "Project 1 Million" to offer broadband access for educational needs. The program provides "qualifying student households with access to broadband products and internet services before the start of the 2020-2021 school year."

## Technology-Driven Development

Nevada has long been a place where industry-shaping technologies are unveiled to a global audience. In recent years, the state has pushed further, facilitating the deployment and scaling of new and emerging technologies, such as unmanned aerial systems (UAS) and autonomous vehicles, and demonstrating their applicability in real-world scenarios. Since the Great Recession, Northern Nevada has managed to attract a number of high-profile technology companies, including Panasonic and Tesla, that have enabled economic diversification and provided new employment opportunities for regional residents. Southern Nevada has also attracted technology firms, such as Switch and Hyperloop One, that have worked to diversify the local economy. Other developments, such as the formulation of the water innovations research and commercialization organization WaterStart, have established Nevada as a thought leader in certain growing technology fields.

Work remains to be done, however, to place technology at the center of Nevada's economy. While new technologies are used throughout Nevada's industries, Nevada has struggled to become a producer and developer of technologies. Recent progress has been made in Southern Nevada to enable the development of new and innovative technologies in the region's dominant industries—gaming, hospitality, and entertainment—through the creation of industry-specific accelerators, like Black Fire Innovation. Expanding the opportunities for technology development and deployment in globally-critical sectors—such as manufacturing, energy, and logistics—will fortify Nevada's economy and place it among key producers of technology.

Investor and mentorship networks for technology-focused startups are relatively underdeveloped in Las Vegas compared to the other metro areas in the country. The COVID-19 impact on co-working and other startup support organizations is high compared to other sectors of the economy, creating an even greater need to strengthen Nevada's startup ecosystem, in partnership with Nevadan organizations like StartUpNV, as well as external ones. A good example is the Innovation District designation by the City of Las Vegas and the launch of the International Innovation Center (IIC). The International Innovation Center will be a hub for the development of new and emerging technologies, including IoT, artificial intelligence, virtual and augmented reality, cybersecurity, water science, and advanced mobile data, and house local and international startups and established companies.

## Establish Southern Nevada as a World Data Hub

Since the Great Recession, Southern Nevada has successfully attracted several firms to establish data centers in the region, most notably Switch and Google. Due to its climate conditions and the low risk for natural disasters, Southern Nevada remains one of the most competitive locations in the United States for data centers. Factors such as available land parcels, energy stability and availability, and the availability of a skilled workforce, are particularly important for the data sector. According to research by the industrial real estate firm CBRE, Southern Nevada ranks competitively among other metropolitan areas for construction and land costs and is middle-of-the-road for labor costs.

Data centers are a catalyst for a wide range of qualitative economic benefits and are attractive assets to Foreign Direct Investment (FDI) in related industries. Data centers and the wider digital ecosystem stimulate growth through knowledge spillovers. Tech-focused FDIs are also considered a major driver of knowledge spillover through labor mobility, market competition, and market transactions with local companies.

Power costs in Las Vegas, however, remain above average for comparative metropolitan areas. One way to address the comparatively higher power costs in Southern Nevada is to increase the deployment of renewable energy sources; a study by the Association for Computer Operations Management (AFCOM) found that nearly 70% of companies that use data centers had either already deployed renewable energy sources or were intending to do so in the next year. Of those companies investing in renewables alongside their data centers, 80% indicated that renewables would help the financial bottom line of the data centers.

The increasing attractiveness of Southern Nevada to technology companies, particularly those looking to establish data centers in the region, heightens the need for a qualified workforce that can meet the needs of these employers. A report by AFCOM identified the top job types that are needed for a strong data center workforce, including cloud facilities and center technicians; operations and controls engineers; and program managers. Each of these career pathways requires highly technical training, much of which is done at the post-secondary level. To position itself for exponentially greater growth in the data center industry, Southern Nevada must pursue education and training programs in these fields at the Clark County School District (CCSD), as well as the region's two- and four-year higher education institutes.

Building out 5G networks and closing other digital divides, like broadband access, Nevada can position itself as the Data Capital of the Mountain West. With the presence of Switch and Google taking a lead, Nevada can claim a leadership position in data storage and become a world-renowned cluster in that business category.

Specific areas of interest include:

- **Facilitate the Deployment of Renewables for Industry** Accelerating the transition to a low-carbon economy by supporting the private sector's adoption of resource-saving technologies
- **Support the Development of Data Center Training Programs** Facilitating the growth of Nevada's skilled technical workforce by expanding training opportunities for middle- and high-skill and -wage occupations at the state's two- and four-year higher education institutions

### **Recruit Automation and Digital Technologies Firms**

The COVID-19 pandemic has accelerated the transition toward greater automation and digitization of many routine and some non-routine tasks. As these technologies mature beyond the laboratory, companies will be looking for opportunities to deploy their innovations in a real-world context. Nevada has demonstrated its openness to being a testbed for autonomous technologies; Reno-Sparks' metro region is home to UNR-led "Living Lab" for autonomous vehicle technologies, while Southern Nevada is host to the Nevada Institute for Autonomous Systems (NIAS) and is an FAA-designated proving ground for unmanned aerial systems, one of a handful in the United States. Such designations will be a valuable feature of the state for companies operating in this space.

The recruitment of automation and digital technologies firms also builds upon the state's push to integrate advanced manufacturing capabilities into the economy. Advanced manufacturing requires

cutting-edge equipment and systems such as those produced by automation and digital technologies firms. Clustering the producers and users of these technologies together creates critical mass in the local economy and incentivizes other firms to relocate to the area.

Specific areas of interest include:

- **Establish an Advanced Manufacturing Applied Research Center Housed Jointly between the University of Nevada Reno and Truckee Meadows Community College** This will support the development of human and knowledge capital in the advanced manufacturing arena to accelerate the growth of Nevada’s advanced manufacturing industry

### Enable Technology-Based Entrepreneurship

Entrepreneurship has been a key focus of Nevada’s recovery from the Great Recession. According to the Kauffman Foundation’s Indicators of Entrepreneurship, in 2018 Nevada ranked 28<sup>th</sup> out of all U.S. states and Washington, D.C. in the percent of population that started a new business, indicating the highly entrepreneurial spirit of Nevadans. However, the data also reveal that the rate at which Nevadans start new businesses has steadily fallen since 2010 and remains well below national levels. Slightly offsetting this decrease in the rate of new entrepreneurs is the increasing number of jobs created by the average Nevadan startup; since 2010, the average number of jobs created by a Nevadan startup has increased from roughly 1.5 to about 2.5, a 67% increase, ranking Nevada sixth in the United States for startup job creation. Likewise, an increasing share of startups in Nevada are formed by choice (75% rather than necessity) though the state remains below the U.S. average and ranks 38<sup>th</sup> overall.

While the above data indicate that Nevada has proven adept at fostering entrepreneurship throughout the state, much of the state’s business creation activity remains concentrated in retail and other service-oriented sectors. There is an important distinction to be made: though “entrepreneurship” may be interpreted as any new business creation, there is a difference between “small business entrepreneurship” and “startup entrepreneurship.” Many newly formed retail and service-oriented businesses would likely be classified as small businesses rather than startups due to their primary focus on local markets and limited interest in scaling nationally or globally. Startups, however, intend to create a new industry or disrupt an existing industry, frequently on an international scale. To do this, many startups spend significant capital on research for a new product or service, often not seeing positive revenue for years.

Encouraging growth in technology-driven entrepreneurship calls for a more intentional approach to entrepreneurship-supportive policies. Due to their focus on developing new products or services, startups require access to knowledge capital and competencies within certain technical domains. Outside of the software space, startups looking to develop new products or services can also be capital-intensive, e.g., in energy or transportation, requiring consistent access to funding sources over longer stretches of time. Mentorship from successful startup founders, as well as venture capitalists, are also valuable resources for those looking to establish technology-intensive startups.

Unfortunately, the COVID-19 pandemic has had a negative impact on startups and small businesses. Globally, 40% of startups are threatened because of the COVID-19 pandemic, and Nevada is not exempt from that statistic. The responsibility of preserving startup companies falls on governments and their willingness to mitigate the impacts through grants, loans, deferring costs, payroll support, and other measures to alleviate investment uncertainty. At the state and local level, it is important to understand the pain points faced by local technology entrepreneurs when forming and scaling their firms. State and local leaders have been effective at doing this for larger tech companies—such as

Apple, Tesla, and Google—enabling the firms to establish a presence in northern and Southern Nevada. A different suite of policies and initiatives will be necessary for enabling technology entrepreneurs to sustain their success.

Specific areas of interest include:

- **Establish a Statewide Network of Angel Investors** Convening Nevada-based investors to support emerging start-ups throughout the state
- **Support Collaboration with Private and Non-Profit Tech Accelerators** Expanding the state’s collaborations with organizations that provide support to Nevada’s entrepreneurs, such as the North Las Vegas Innovation Collective
- **Conduct a Study of Missing Tech Ecosystem Components** Identifying the shortcomings of Nevada’s current tech ecosystem to enable more effective tech-centric policies and programming
- **Close Funding Gaps by Creating a Statewide Seed Fund** Accelerating the growth of Nevada start-ups by providing direct support to entrepreneurs operating in key sectors of the economy
- **Design a Cohesive Strategy to Enhance the Existing Nevada Global Business Recruiting Platform** Positioning Nevada as an ultra-competitive soft-landing region for high-growth technology startups from around the world
- **Create Mechanisms to Identify, Match, and Support a Wide Pool of Mentors** Establishing a cohort of mentors that can provide guidance and assistance to Nevada’s entrepreneurs
- **Create a Diverse Innovation Ecosystem** Enabling the growth of women and minorities in STEM fields

## Responsible and Sustainable Growth

Nevada has consistently demonstrated a dedication for embracing sustainability as it develops and diversifies its economy. Since March 2016, the state has been a signatory of the U.S. Climate Alliance, which commits the state to a reduction in greenhouse gas emissions of over 25% by 2025. Not only has the state looked to reduce its impact on the environment to mitigate its contribution to climate change, but Nevada has also viewed sustainability as an economic opportunity on which it can capitalize. According to the U.S. Climate Alliance, member states created more than 1.5 million jobs in clean energy between 2013 and 2016, bringing the total employment in clean energy in these states to more than 10 million. Of the 25 member states, Nevada experienced the most significant growth in clean energy jobs, witnessing a 100% increase in clean energy employment between 2013 and 2016.

Nevada is well-positioned to maintain growth in the clean and green economy. As electric vehicles become more commonplace throughout the world, and as renewables achieve further integration within national electric grids, the need for energy storage solutions will increase significantly. Nevada has the opportunity to place itself at the center of energy storage supply chains, in large part due to its enormous reserves of lithium. There is also potential for Nevada to export its expertise in water conservation and management, for which the state has become internationally renowned. It will be critical for state and local agencies to facilitate the actions of key players in these areas so that utilities, transportation networks, and consumers can move rapidly toward a sustainable future.

## Lead the Global Development of Energy Storage Supply Chains

Mining has long been a significant component of Nevada’s economy and the discovery of large lithium deposits in Northern and Central Nevada positions the state to be a global leader in lithium production. Lithium plays a critical role in many new and emerging technologies especially those concerned with energy storage for electric vehicles and electric grids. The mining of lithium provides a catalyst for Nevada to develop a new component of its mining industry that is intimately connected to the global value chains in technology development and production. Likewise, the processing of other critical materials and minerals beyond lithium that are key to U.S.-based technology production and development would position Nevada well within the national security apparatus, securing the state as a key component of U.S. technology supremacy.

Nevada is currently well-positioned for this transition. The opening of Tesla’s Gigafactory in Northern Nevada served as a critical first step in realizing the state’s role in global energy storage supply chains. However, despite Nevada’s significant known and probable lithium reserves, Tesla is forced to import lithium from outside of the United States for inclusion in their batteries. Development of Nevada’s lithium sector not only closes a critical gap in Nevada’s energy storage production but also enables Nevada to become a net exporter of lithium. In fact, the expected yield of Thacker Pass, the region of Northern Nevada that is proposed for lithium mining, may potentially fulfill % of today’s global demand for lithium once the proposed mining development reaches full capacity.

Specific areas of interest include:

- **Accelerate the Convergence of In-State Lithium Mining and Production** Enabling the centralization of lithium procurement and refinement within the state of Nevada
- **Solidify Nevada’s Role in the Global Energy Storage Supply Chain** Growing Nevada’s lithium operations to position the state as a key player in the global energy storage supply chain

## Transition to a Low-Carbon, Low-Emission Economy

Nevada’s Climate Strategy has committed to a reduction in greenhouse gas emissions of over % by and net-zero near zero by. The state has made progress on this goal through several recent developments including widespread solar energy deployment and electric vehicle adoption. The state’s energy provider, NV Energy, remains committed to further usage of renewable energy technologies and adopting a greater variety of renewable energy sources. It has partnered with higher education institutions throughout the state, providing million-dollar grants to the University of Nevada, Reno (UNR) and the University of Nevada, Las Vegas (UNLV) to develop a geothermal studies program (UNR) and a renewable energy studies program with an emphasis on solar energy (UNLV).

In recent years, NV Energy has also begun harnessing emerging technologies—including drones—to monitor Nevada’s energy transmission network and identify potential fire threats. In deploying renewable energy technologies in the state’s energy infrastructure network, however, NV Energy has faced challenges. Before making an investment in renewable energy infrastructure, the proposed project is assessed by the Public Utilities Commission of Nevada (PUCN) using a cost-of-service-based framework, which does not take into consideration many of the current values held by energy infrastructure stakeholders, such as reducing carbon emissions. However, PUCN is obligated to use the cost-of-service framework by historic public statutes, making it difficult for the regulator to assess proposed investments according to newer standards tied to green energy. A scorecard approach—for example, one that examines the number of jobs created by a proposed project and the expected

carbon reduction—would better enable NV Energy to flexibly integrate renewables into the state’s energy network

Specific areas of interest include:

- **Evaluate PUCN’s Investment Review Framework** Re-evaluating PUCN’s cost-of-service approach and integrated resource planning process for reviewing energy infrastructure investments to identify areas for modernization such as moving toward a performance-based approach that enable the use of new metrics for investment assessments
- **Expand Nevada’s Electric Vehicle Charging Network** Partnering with Nevada’s energy providers to significantly expand the state’s electric vehicle charging network to enable greater adoption of electric vehicles
- **Build research capacity across UNR UNLV and the Desert Research Institute in renewable energy** Reaffirming Nevada’s commitment to excellence and leadership in renewable energy by supporting research in key areas of renewable energy technologies

**Transition to Water-Wise Economy**

The climatic conditions to which Nevada has long been accustomed have required the state to be innovative in how it exploits its water resources. Local governments, particularly in Southern Nevada, have incentivized residents to forego the typical greenery that is common in many suburban developments in favor of drought-tolerant landscaping that is more typical of the state’s mostly desert climate. Initiatives such as these have helped to increase the resiliency of Nevada’s communities, while also creating new opportunities in the development of water conservation technologies.

The foundation of WaterStart in \_\_\_\_\_ served as a catalyst for the emergence of Nevada’s water conservation expertise. Through the commercialization assistance provided by WaterStart, Nevada has attracted companies developing key technologies to conserve water resources. Scaling these technologies—not only throughout the state, but also across the United States and internationally—represents a significant opportunity for Nevada to achieve a water-wise economy and grow an economic sector that is sure to be in demand as the consequences of climate change are felt across the globe.

Specific areas of interest include:

- **Bring smart meter pilot program to scale statewide** Determine how to scale smart meter pilot program across the state
- **Study Northern Nevada Development Authority’s NNDA effluent water proposal** Lift potential constraints on future industrial and residential development
- **Expand WaterStart’s water-tech company recruitment** Recruit into the existing water-tech cluster through the attraction of WaterStart programs and partnerships

**Comprehensive Placemaking**

Nevada has experienced some of the nation’s most rapid population growth over the last decade. While much of the growth is concentrated in the state’s two major urban areas, Reno-Sparks and Las Vegas, the growing opportunity for remote work due to the COVID-\_\_\_\_\_ pandemic opens much of Nevada’s frontier to a new class of digitally- and geographically connected worker. Workers that were once constrained to urban and suburban localities due to their proximity to business now have the opportunity to relocate to areas that are more affordable and offer a better lifestyle. Nevada’s

connectivity particularly via air travel and low cost of living make it a competitive destination for these workers

To fully capitalize on the new geographies for living and working brought about by the COVID-pandemic a clear understanding of Nevada's communities is necessary. Mapping the benefits and challenges of living in Nevada's communities will help determine where interventions are necessary to ensure Nevada can meet the needs of a vibrant diverse population. Some pain points such as healthcare access have been identified previously and remain imperative especially during a pandemic. Other areas of interest like placemaking are newer but comprise an integral component of defining what it means to be a community in Nevada.

### **Remove Barriers to Healthcare Access across Nevada**

Timely access to quality healthcare has been a consistent obstacle for many Nevada residents that has worsened due to the COVID-pandemic. According to the Association of American Medical Colleges' AAMC State Physician Workforce Data Report Nevada ranks 47<sup>th</sup> in the nation for the number of active physicians per 100,000 residents. The data are worse for the number of active primary care physicians and active general surgeons in the state where Nevada ranks 50<sup>th</sup> and 48<sup>th</sup> respectively. Around 12% of Nevada's active physicians are international medical graduates the eighth highest rate in the United States indicating an intense need to recruit medical professionals to the state. In Nevada's urban regions a lower-than-average number of primary care physicians means that many Nevadans face long wait times when seeking medical care. In Nevada's rural communities long wait times are compounded by a lack of local options requiring residents to drive to more urbanized areas of the state for medical procedures.

While Nevada has struggled to develop home-grown healthcare talent much progress has been made on this front in recent years notably through the establishment of the University of Nevada Las Vegas UNLV School of Medicine as well as the formation of several nursing programs at the state's two- and four-year colleges. According to AAMC's data of those physicians who completed their graduate medical education GME in Nevada about 65% chose to practice in the state ranking Nevada sixth in the United States for graduate medical student retention. However Nevada again ranks poorly 47<sup>th</sup> in the nation for the number of medical residents and fellows enrolled in accredited programs. Additionally of all the active physicians in Nevada slightly more than 10 percent received their GME in California not Nevada. As Nevada is clearly successful at retaining physicians who complete their GME in Nevada further expanding opportunities for medical students to complete their residencies in Nevada may better enable the state to grow its healthcare workforce.

The COVID-pandemic has demonstrated the need for an adequate healthcare workforce in the state's localities. It has also illuminated the need for a greater diversity of healthcare access points aside from physical healthcare facilities encouraging medical professionals to meet patients where they are located. By minimizing the need for individuals to physically go to see a medical professional Nevada can reduce the strain on the state's healthcare industry and increase the total number of patients a physician can see. Telehealth has become an area for growth within the healthcare industry enabling individuals to access medical expertise for non-emergency conditions from their homes. Assembly Bill 450 enabled greater development of telehealth services in Nevada and the COVID-pandemic has necessitated a dramatic increase in the use of telemedicine. Increasing the opportunity for telehealth throughout Nevada particularly in the state's rural and frontier communities requires investments in the state's digital infrastructure especially broadband connectivity.

Specific areas of interest include:

- **Expand Opportunities for Residency Programs at Nevada’s Hospitals** Reduce the shortage of medical professionals by recruiting newly graduated physicians to Nevada’s hospitals
- **Expand Broadband Access in Nevada’s Rural and Frontier Communities** Based on Project ECHO expand the capacity of health professionals to treat disease via telehealth
- **Address Low Medicaid Reimbursement Rates** Encourage the establishment of more hospitals by raising reimbursement rates
- **Join the Enhanced Licensure Compact** Eliminate barriers to mobility for medical professionals

**Encourage Purposeful Residential and Commercial Zoning and Development**

Nevada’s housing market has recovered significantly from the pain inflicted by the Great Recession. As the state has continued to attract new residents at a record pace, new construction of mostly single-family homes has risen to accommodate this growth. Home prices also rose as the state exited the recession. According to the Lied Center for Real Estate at UNLV, whereas the average new single-family home in Southern Nevada sold for around \$150,000 in June 2012, the price had risen 25% to \$187,500 in June 2013. A similar trend has been observed in the Reno-Sparks area, where the average new single-family home price rose 15% from \$120,000 to \$138,000 between June 2012 and June 2013. There has clearly been a shift in builder preference for more lucrative, high-end homes in Nevada’s two primary urban areas.

The increase in pricing of new single-family homes is further compounded by the increase in pricing of existing single-family homes during the same period— 10% to \$160,000 in Southern Nevada and 15% to \$172,500 in Northern Nevada. Across-the-board increases in the price of home ownership contribute to the polarization of local housing markets, where median earners are faced with fewer affordable options and are forced to compete for a smaller amount of housing stock, which can drive prices further.

It is important that Nevada’s urban, suburban, and rural communities meet the needs of a socioeconomically diverse population. This may require a more comprehensive approach to zoning and planning in Nevada’s communities, where residential, commercial, and retail spaces are co-located to enable further population growth without inundating existing transportation infrastructure. Likewise, ensuring that affordable housing options are integrated into future residential development plans allows for a greater diversity of individuals to engage in Nevada’s communities.

The situation for commercial property is especially challenging because of the shortage of sites of the appropriate size. Indeed, a recent study sees land rather than water as the principal constraint on the development of Clark County in the years ahead. The region is projected to require about 10,000 acres of developable employment land to meet the needs of the expected economic and job growth by 2020. Given that only 5,000 acres are available that are optimal for development, there is the possibility of a 5,000-acre shortfall by 2020.

Specific areas of interest include:

- **Lobby for the Southern Nevada Public Land Management Act (SNPLMA)** Immediately and aggressively pursue changes to federal law to release additional space for development

## Expand the Outdoor Recreation Economy

The COVID-19 pandemic has encouraged individuals to engage with their local and regional outdoor amenities. According to the U.S. Department of Agriculture Forest Service, this renewed attention in the American outdoors as a result of stay-at-home orders and restrictions on indoor entertainment is built upon a trend that has been growing in the United States since the late 1980s. On a national scale, outdoor recreation has grown to a \$100 billion industry that directly employs more than six million people.

While the “recreation economy” has long been present in Nevada, COVID-19 has reinvigorated interest in the state’s outdoor assets. Prior to the pandemic, the Nevada outdoor recreation economy directly employed 100,000 workers, generating nearly \$10 billion in consumer spending, \$1 billion in wages and salaries, and over \$1 billion in state and local tax revenue. Nevada has taken steps to recognize the potential the outdoor recreation economy represents for the state, notably through the creation of the Nevada Division of Outdoor Recreation (NDOR) in 2019.

Continued development of the state’s outdoor recreation portfolio can increase the quality of life for residents of Nevada’s urban areas by providing opportunities for outdoor exploration while increasing economic opportunity for residents of Nevada’s rural communities. Housed within the Department of Conservation and Natural Resources, NDOR will also ensure that the growth of this industry does not come at the expense of the health of Nevada’s public lands.

### Specific areas of interest include:

- **Expand the scope of the Statewide Comprehensive Outdoor Recreation Plan** Coordinate outdoor recreation infrastructure planning and implementation with small business development in rural communities.

## Support Entrepreneurship in Digital Arts and Esports

Entertainment has been an integral component of Nevada’s economy. As creative content has increasingly become digital and easier to consume without requiring individuals to travel to one particular destination, a shift toward becoming a hub for digital arts creation provides local creatives the opportunity to produce and share their works to a broader audience.

Entrepreneurship in the digital arts goes beyond the creation of digitized art. Indeed, emerging areas like game design are also a significant area of growth in Nevada, especially in Southern Nevada. The emergence of esports as the new frontier in gaming and digital entertainment will allow for a new class of digital artist. Access to resources, such as game design studios and equipment, will enable entrepreneurs in this space to hone their skills and develop industry-leading games in Nevada. The presence of the gaming industry throughout the state provides these entrepreneurs with a built-in test bed for their games and the potential to scale beyond the state.

### Specific areas of interest include:

- **Create a Digital Arts Studio in Southern Nevada** Within the UNLV innovation district, provide the infrastructure necessary for digitizing the performing arts.



Nevada's Plan for Recovery & Resilience

# Capabilities to Realize the Vision

The Future Beyond the Pandemic

## Capabilities to Realize the Vision

In order to realize these strategies for the future Nevada will need to build or rebuild key financial and institutional capabilities and develop realistic statutory actions. The capacity of the state and its associated institutions is stretched to the limits by the current crisis. Nevadans have preferred a low-capacity state government dispersed over three cities. But Nevadans cannot prosper in the future without accepting the need to invest in real management and financial capabilities. This does not necessarily mean a large government rather it calls for an effective government. To be effective systems must be modernized and institutions reformed. Such initiatives would include those listed below:

- Fully fund the state infrastructure bank
- Establish a sovereign wealth fund
- Reinvent the Knowledge Fund and build a network of innovation and evergreen venture funds
- Establish a single state office in support of Micro- Small- and Medium-Enterprises MSME
- Grow Nevada's community banking network
- Modernize Nevada's fragmented administrative systems
- Redesign governance and funding mechanisms for the community college system

## Fund the State Infrastructure Bank

Nevada needs to make significant investments in infrastructure if it is to keep growing its economy. However, the state's ability to raise money is more limited than that of most states; for example, Nevada's state constitution bans toll roads. In response to these challenges, Nevada lawmakers passed AB 117. This measure, commonly known as the "infrastructure bank bill," created the framework for the Nevada State Infrastructure Bank in order to fund roads, bridges, and other projects across the state. Such an institution not only allows the state to mobilize its own ability to borrow but provides an institutional environment ready to respond to federal infrastructure initiatives. Such initiatives, although much talked about, have not yet materialized.

However, as the scenarios laid out at the beginning of this report indicate, recovery from this crisis may take a long time. Capital will be cheap, labor will be available, and it will be vital to complete the capital projects discussed in the section above if the state's economy is going to grow in new, more resilient directions.

The first order of business in building Nevada's capabilities for the future is to capitalize the bank, which at present is an empty shell. This could be achieved in a variety of ways, but seed funding from the state employee's retirement plan could be a viable path, although CARES act funding may also be a possibility if constraints on the use of that funding allow. Given the list of projects already identified across the state with a high ROI, it would be easy to then obtain other investors in the bank.

## Establish a Sovereign Wealth Fund

Sovereign Wealth Funds (SWF) are often used to smooth out public-sector revenues by calling on savings obtained from taxing natural resources, mitigating the necessity of funding substantial rainy-day funds out of general fund revenues. There are many examples of SWFs in the United States and around the world (see the list of U.S. states with sovereign wealth funds in Appendix C). Some states obtain modest revenues, although they can be vital in a crisis. New Mexico was able to shore up many small businesses early in the present crisis by calling on its SWF. Other states can use them in transformational ways: The University of Texas benefits from a Permanent University Fund that now exceeds \$10 billion.

Nevada has several possible sources of revenue from which to draw in order to fill the fund. More important at this stage is to set in place an institution that was truly independent and transparent. Many models exist. Voters may have reservations about revenue that disappears into the general fund. A sovereign wealth fund tasked by statute with supporting applied research for business and workforce development would increase the confidence of the voters that the revenues were being invested in the state's future. A model could be the Golden Leaf Foundation in North Carolina.

## Establish the Nevada Innovation Fund

Nevada's Knowledge Fund has recorded some high-profile successes in innovation and entrepreneurship. However, Knowledge Fund investments to date have mainly established sustainable research infrastructures and conduits of access for private companies to Nevada's three main research institutions. This approach has provided research services and a talent pool to industry and helped to support projects in obtaining federal research grants (DARPA, NIH).

However, a changed mindset is required at the universities. Such a fund is not best thought of as an opportunity to build capacity. It is an opportunity to fuel business-based innovation in partnership with universities. A Nevada Innovation Fund, a new vision in this space, would make investments

targeting tech commercialization spin-out company formation and monetization of IP from research institutions; it would also support the growth of entrepreneurial ecosystems up to and including direct support of tech companies

Such a fund could work in at least four ways:

- **Innovation Capacity Building:** Grant funding for applied R&D infrastructure and projects at Nevada System of Higher Education NSHE similar to Knowledge Fund projects Emphasis on university/private industry partnerships
- **Innovation Transfer:** Grant funding for technology transfer projects at NSHE and private companies through Small Business Innovation Research/Small Business Technology Transfer SBIR/STTR matching program Focus on Technology Readiness Level [TRL] –
- **Innovation Acceleration:** Grant funding to accelerate innovation for private early-stage Nevada tech companies to help them scale best practice: USTAR TAP Creation of acceleration and venture building programs through collaboration with outside organizations e.g. Rainmaking – UNLV Support for Entrepreneurial Service Organizations ESOs to include mentoring networking entrepreneurial training for private entity or university researcher
- **Innovation Ventures Seed Funding:** Through non-profit Nevada Battle Born Growth Escalator Inc NBBGE Assistance with creation of Independent Commercialization Entity to offer NSHE path to effective formation of spin-out companies while providing investors with clarity of ownership structure Equity-based investment to early-stage companies with high potential to scale through NBBGEI Focus should be on NIF/KF project linked spin-outs

## Establish an Office for Micro-, Small-, and Medium-Sized Enterprises (MSME) within GOED

Support for MSME is especially important for a state like Nevada The state is home to an enterprising population known for pursuing gig work alongside regular employment lifestyle entrepreneurship or businesses in the arts and outdoor recreation or opportunities available from family-run businesses especially valuable to recent immigrants In short MSMEs are a source of economic dynamism and often an important step on the economic ladder for immigrants and other disadvantaged populations

However responsibility for state policy towards MSMEs is spread across three parts of state government: The Department of Business & Industry B&I GOED and the Nevada System of Higher Education NSHE through its Small Business Development Centers SBDC As a result there is limited coordination and conflicting communication with no single office or leader charged with owning all of the issues of importance to this sector

Self-Employment Assistance SEA is an example of the kind of initiative such an office could coordinate Five states — Delaware Mississippi New Hampshire New York and Oregon — have implemented this federal program that facilitates small-business startups States that opt in can pay dislocated workers a weekly SEA allowance—the same amount that an individual would receive in unemployment benefits—with the individual encouraged to work full-time on his or her new venture instead of seeking a job SEA also supports a wrap-around infrastructure through which participating individuals receive entrepreneurial training business counseling and technical assistance

In the last legislative session the Lt Governor proposed an Ombudsman in her office to troubleshoot small business issues This is a move in the right direction but could be amplified by moving

the small business function from B&I to GOED. With the Lt. Governor serving on the board of GOED, this could create a working group and point of contact for small business inside GOED, led by the Lt. Governor, that addressed the present fragmentation of policy.

## Grow Nevada's Community Banking Network

Community banks were essential to the success of the Paycheck Protection Program (PPP) in the present crisis. It was designed in a way that made community banks integral to its success. \$350 billion was distributed in the four months from April through August, and community banks with \$1 billion or less in assets made about 40 percent of the overall number and value of PPP loans. But Nevada is grossly underserved by community banks, and as a result was relatively slow to benefit from the PPP.

Community banks are small, but they play a big role in local economies. A community bank is a bank which has specialized knowledge of their local community and their customers and base credit decisions on local knowledge and information obtained through long-term relationships. They receive deposits from sources within a town or city and lend that money to local businesses to create balance within that economy. Because community banks consider history and reputation of their customers when making decisions, they invest themselves in their customer's success and offer assistance, training, and support beyond that of national institutions.

Such banks can take many forms, both private and not-for-profit. Most are certified by the federal government and are eligible for government support through the federal CDFI Fund, as well as private funding. Nevada's regional leaders should mobilize partnerships of key regional institutions in support of their formation. This will enrich the ecosystem in which MSMEs operate and help ensure their success.

## Modernize Public Policy and Governance

### Introduction

As individuals, families, businesses, schools, and communities across Nevada work to recover from the public health and economic devastation brought about by the COVID-19 pandemic, elected officials have an opportunity to enact a series of reforms to modernize state government. These efforts should address structural deficiencies in government operations and policy issues including workforce, economic development, and taxation. For example, the Nevada Governor's Office of Science, Innovation & Technology (OSIT) should be empowered to establish enterprise-wide information technology systems comparable to initiatives in Utah and Colorado. It is a given that Nevada is behind in adapting technology for the delivery of government. By contrast, Arizona implemented a cloud-based management system that ends the "reliance on paper, outdated procedures, and decentralized management [that] can hamstring a state's ability to disperse and track funds."

The COVID-19 pandemic demonstrated that states must operate in a 21<sup>st</sup> century technological environment. State employees require basic infrastructure to perform their duties. Laptop computers without cameras are not a budget savings measure if state workers cannot participate effectively in virtual meetings. Requiring paper copies of standard forms, accepting fax copies but not pdf documents, and being unable to respond to email inquiries is unacceptable.

Nevada's efforts to manage federal stimulus funds, to administer healthcare and social services, most notably unemployment insurance, and to conduct legislative operations during the summer

legislative special sessions demonstrate that relying on antiquated technology and outdated policies and procedures fail to serve the state

### **Federal Funds**

The state faces a period of austerity in its finance system making it critical for state agencies to become more sophisticated in securing federal funds to support important services and ongoing policy priorities. Budget and policy decisions should be strategic and not reactionary to fiscal deficits. Where cuts need to be made, it must be done in a way that ensures the state does not lose matching federal funds. Nevada has recently taken steps to improve its acquisition and management of federal grants. When the state fails to pursue federal resources, the funds are distributed to other regions, placing Nevada further behind its peers.

Local and state leaders across the nation are accessing federal programs and developing public-private partnerships to bring resources to their communities. The Brookings Institution highlighted a sampling of innovative programs that engage idle restaurants, explore online job recruiting tools including new “apps,” apply federal grants and public-private partnerships to help small businesses and champion racial and social equity measures among others.

### **Boards and Commissions**

Nevada relies on boards and commissions with statewide responsibilities to oversee many government and economic sectors. Despite their importance, these bodies often do not reflect the state’s current population distribution and operate with antiquated charges that reflect a smaller, more homogenous, and rural-oriented state.

For example, based upon an executive branch audit, Governor Sisolak’s administration found that many of the state’s occupational boards were misaligned and underperforming. Utah and Colorado have created a division of occupational licensing within their departments of commerce, a model suitable for B&I to follow. One benefit is easing the transfer of credentials for trailing spouses, often an obstacle to recruiting professionals to Nevada where both partners work. This suggests that these boards and commissions require additional reforms and greater oversight to improve performance and representation.

Two recently created boards and commissions demonstrate state government adapting to changes in economic and social needs. The Cannabis Compliance Board focuses on marijuana policy and regulation in a manner similar to Nevada’s Gaming Control Board. The Patient Protection Commission recently voted to focus its work “on healthcare issues facing the state, including workforce development, COVID-19 response, and telehealth.” The body is even authorized to bring bill drafts directly to the legislature.

These two new entities can serve as models for a review and modernization of existing Nevada boards and commissions. Such a review may identify and recommend the creation, dissolution, or merging of existing boards or commissions.

### **Taxation**

Nevada’s system of tax and finance rests on a narrow base, in particular on a single industry, tourism. This leaves the larger Nevada economy vulnerable to economic disruptions, such as the downturn brought about by the COVID-19 pandemic. During the first three months of the pandemic, Nevada lost 100,000 jobs. In April, alone, visitation dropped 40%. To this end, a Legislative Study Commission or similar body could explore alternative revenue sources designed to broaden

the tax base in order to limit volatility in revenues and ensure that the base tracks future change in the economy

Another element to consider in the state's system of taxation is to draw on regional economic activity to support local services and infrastructure investments. The concept of regional taxes is not new. In Nevada, any consideration of regional taxes must reflect the state's economic geography. Mining, to a large extent, takes place in rural Nevada, while gaming and live entertainment concentrate in Southern Nevada. The introduction of legalized cannabis generated new state and local tax revenue and also raised conversations about its geographic allocation.

Mining is treated as a regional tax, with a portion of revenues reserved for the localities where the resource is located. A similar carve out of the live entertainment tax to support local services and infrastructure, reflecting the concentration of industry and associated costs, would parallel the current tax arrangement for mining in rural Nevada.

## Reinvent Nevada's Workforce Institutions

The sections below highlight governance, funding, and workforce development as it relates to the state's community college systems. Options are considered for reforms to integrate innovation and workforce assets to help grow and diversify the state's economy.

### Governance and Administration for Workforce Institutions

Nevada's regional institutions need active, locally recruited advisory boards with representation from sector industries that are within the campuses' service areas. These boards will be able to work directly with leadership to develop and assess campus policies, priorities, and performance. Aligning these institutions with regional constituencies will position the campuses to develop partnerships with local industry and governments. Examples from across the country demonstrate the benefits for workforce development and economic diversification that result from locally focused college governance.

### Funding

The ideas presented below are designed to more effectively align resources to support the campuses' differing constituencies and missions, particularly as they relate to economic development.

Implemented in \_\_\_\_\_, the current formula used to distribute operational funding to the teaching institutions places these colleges at a disadvantage as they compete against the universities for a finite resource. In order to address these shortcomings, the state should develop separate formulas for the universities and colleges that reflect these institutions' differing missions, service areas, and student needs. Resources should be dedicated to students who are Pell-grant eligible and first-generation attendees to support their onboarding, advising, and mentoring. Furthermore, credentials, certificates, and other competency-based curricula should be fully rewarded under the formula for workforce institutions.

The non-alignment between Nevada's colleges and the mix of degrees and certificates awarded also has implications for accessing federal resources. Truckee Meadows Community College (TMCC) most comports with the federal government's definition of a community college, although that was truer several years ago than today as the school expands its four-year programs. As a consequence, TMCC was the primary intake for federal workforce training funds during the Obama administration. Yet the campus serves a region with just \_\_\_\_\_% of the state's population. Out of the \_\_\_\_\_ billion in Trade

Adjustment Assistance Community College and Career Training TAACCCT grants awarded nationally between and by the U.S. Department of Labor Nevada received less than million

Nevada needs genuine community colleges based in their communities Nevada should redefine College of Southern Nevada CSN TMCC and Western Nevada College WNC to align with the federal government's definition of a two-year college These colleges should focus on articulation certification remediation stackable credentials and work-place learning They should serve as the principal institutions for public-private workforce development collaborations In the recovery from the current economic crisis the federal government may fund workforce development and retraining initiatives as it did during the Great Recession Nevada would be much better positioned to receive federal resources with three IPEDS-defined two-year colleges

Conversely Great Basin College GBC which offers bachelor's degrees in both arts and sciences a degree portfolio consistent with a four-year school should be reclassified as such GBC should be elevated to a full four-year institution and place the Elko micropolitan area on a par with its regional peers such as Durango Colorado and Clovis New Mexico—both of which maintain four-year institutions that also offer limited graduate education Elko lies at the center of an enormous rural space where the most proximate four-year college is the University of Utah miles away The lack of human capital in the area creates an over-reliance on mining leaving the Elko area vulnerable to market swings in gold prices Just as Las Vegas' economic health is over-reliant on a single industry the same is true for many remote communities

### **Reimagining Nevada's Higher Education Institutions**

The first step in better connecting higher education and industry requires transitioning from the current "state-controlled" university structure to an "academic enterprise" model as exemplified by Arizona State University ASU Academic enterprise institutions such as ASU focus on "social transformation" A hallmark of this approach is public-private partnerships that attract external resources for infrastructure investments and research initiatives ASU vastly expanded its physical plant by offering private firms access to its nonprofit tax status in exchange for developing facilities that are shared with partners For instance State Farm's western headquarters was built on land leased to it by ASU and thus qualifies for property tax exemptions In exchange ASU receives academic space and funding including a million donation for its career development program

Nevada's universities should pursue ASU-style public-private partnerships with multiple industrial and private collaborations in order to expand their research and teaching capacities in an era of very restricted state resources UNLV began switching to this approach in to develop its medical education building via a non-profit development corporation While this particular project was developed in partnership with local philanthropy it nonetheless establishes a flexible method for using external resources to build what previously would have been a mostly state-funded and state-controlled building The answer to the prospect of limited state support in the future is to engage multiple stakeholders including local governments with common interest in constructing academic facilities that will sustain applied technology and startup enterprises

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## Appendix B: Timeline of Nevada COVID-19-Related Major Events

- March : WHO declares a pandemic
- March : President Trump announces a national state of emergency
- March : Governor Sisolak issues Directive closing schools and non-essential government facilities as well as ordering essential government services to transition to online and phone services to the greatest extent possible
- March : Governor Sisolak issues Directive closing nonessential businesses statewide including Strip resorts
- March : Governor Sisolak announces new COVID- response task force
- March : Governor Sisolak issues Directive limiting indoor and outdoor gatherings to people
- March : President Trump signs the CARES Act
- March : Governor Sisolak issues Directive a statewide moratorium on residential and commercial evictions
- April : Governor Sisolak issues Directive extending previous orders as well as enacting a statewide stay-at-home order
- April : Governor Sisolak issues Directive activating the Nevada National Guard to assist with the state’s response to the COVID- pandemic
- April : Federal government approves Nevada’s request for a major disaster declaration paving the way for federal financial assistance
- April : Governor Sisolak issues Directive extending the statewide shutdown order to golf courses and religious establishments
- April : Governor Sisolak announces framework for reopening the state largely following White House guidelines
- April : Governor Sisolak issues Directive to extend the stay-at-home order while some certain restrictions lifted
- April : Governor Sisolak releases “Nevada United Roadmap to Recovery” amid plan to reopen state economy under “Phase ” restrictions
- May : Governor Sisolak issues Directive enacting Phase of the economy reopening plans
- May : Governor Sisolak declares a fiscal emergency
- May : Interim Finance Committee transfers M balance of rainy-day fund to the state general fund
- May : Governor Sisolak issues Directive enacting Phase of the economy reopening plans
- June : Governor Sisolak issues Directive to ease restrictions on youth sports and to empower local governments to increase restrictions to limit the spread of COVID- as they see necessary
- June : State releases “Nevada COVID- Outbreak Management Strategy and Concept of Operations” to develop an operations surge strategy to prevent the spread of COVID-
- June : Governor Sisolak issues Directive mandating the use of masks in public spaces
- June : Governor Sisolak issues Directive easing restrictions on evictions
- July : Governor Sisolak convenes a special session of the Nevada Legislature to address the state budget

- July : Governor Sisolak issues Directive which reverts bars that serve food in counties with elevated levels of disease transmission to Phase and again shuts bars that do not serve food
- July : Clark County School District announces most classes will be held online to start the fall semester
- July : Governor Sisolak issues Directive to provide guidelines to county school districts on the reopening of schools
- July : Governor Sisolak convenes a second special session of the Nevada Legislature to address several issues

## Appendix C: Supplemental Tables

Table 5: Variables Used for RCG Economics' Analysis

Variable	Geography
Industry-Level GDP	Nevada
Taxable Retail Sales	Nevada Clark County Washoe County
Total Nonfarm Employment	Nevada Las Vegas MSA Reno-Sparks MSA
Unemployment Rate	Nevada Las Vegas MSA Reno-Sparks MSA
Unemployment Insurance Claims	Nevada
Visitor Volume	Nevada Las Vegas MSA Reno-Sparks MSA
Property Tax	Nevada Local Government & School Districts
Room Tax	Nevada Local Tourism Clark County School District
Gaming Tax	Nevada Clark County Washoe County
Sales & Use Tax	Nevada Clark County Washoe County
Consolidated Tax	Nevada Clark County Washoe County
Modified Business Tax Collections	Nevada
Marijuana Tax Collections	Nevada

Table 6: Sample of U.S. States with Sovereign Wealth Funds and Their Characteristics

State	Fund	Funding Source	Funding Purpose	Value
Texas	Permanent School Fund	Sale of public lands	Education	B
	Permanent University Fund	Rents on public lands Resource rents	Education	B
Alaska	Alaska Permanent Fund	Resource rents	Dividends for residents	B
New Mexico	New Mexico State Investment Council	Resource rents Tax revenue Appropriations	Education Health Infrastructure General fund	B
Wyoming	Wyoming Permanent / Endowment Funds	Resource rents Tax revenue Sale of public lands Rents on public lands Appropriations	Education Public institutions Worker compensation General fund	B
North Dakota	North Dakota Legacy Fund	Resource rents	General fund	B
Alabama	Alabama Trust Fund	Resource rents	Infrastructure Local government Land conservation Senior services General fund	B
Utah	State School Fund	Sale of public lands Rents on public lands Resource rents	Education	B

Oregon	Oregon Common School Fund	Sale of public lands Rents on public lands Resource rents	Education	B
Louisiana	Louisiana Education Quality Trust Fund	Resource rents	Education	B
Montana	Coal Severance Tax Trust Fund	Resource rents	Economic development Education General fund Infrastructure Land conservation	B
	Public School Trust	Sale of public lands Rents on public lands Resource rents	Education	B
West Virginia	West Virginia Future Fund	Resource rents	Education Workforce development Economic development Infrastructure	B projected
Idaho	Endowment Fund Investment Board	Sale of public lands Rents on public lands Resource rents	Education	B
<p>Note: The New Mexico State Investment Council is comprised of four sovereign wealth funds: Land Grant Permanent Fund      Severance Tax Permanent Fund      Tobacco Settlement Permanent Fund      and Water Trust Fund</p> <p>The Wyoming Permanent / Endowment Funds is comprised of eight investible funds: Permanent Wyoming Mineral Trust Fund   Permanent Lands Fund   Hathaway Scholarship Endowment Fund   Excellence in Higher Education Endowment Fund   Workers Compensation Fund   Legislative Stabilization Reserve Account   Pool A   and State Agency Pool</p>				

## Appendix D: Forecasted Impact of COVID-19 on Nevada State & Local Taxes

### Property Tax

Regarding the tax estimates because the distributions between the state and sub-state levels are stable and in some cases see *Methodology* section calculated as a fixed share of the state-level revenues the trends are very similar

The Property Tax estimates show relatively small hits to total state and local collections from about % to % based on the scenario compared to No-Pandemic This appears reasonable based on the continued strength of the housing market nationally and in the state

Table 7: Forecasted Change in Property Taxes in Q4 1 Compared to Expected Property Taxes Under No-Pandemic Scenario in Millions Source: RCG Economics

	Best Case	Most Likely	Worst Case
Nevada	-	-	-
Local Government & School Districts	-	-	-

### Gaming Tax

As the Gaming Tax is heavily dependent on visitation these revenues are highly vulnerable during the pandemic Relative to the No-Pandemic case the Worst Case would see drops in Gaming Tax collections of up to almost % in The Most Likely scenario predicts a % drop and the Best Case a % drop

Table 8: Forecasted Change in Gaming Taxes in Q4 1 Compared to Expected Gaming Taxes Under No-Pandemic Scenario in Millions Source: RCG Economics

	Best Case	Most Likely	Worst Case
Nevada	-	-	-
Clark County	-	-	-
Washoe County	-	-	-

### Room Tax

Estimates on the Room Tax show potential drops of % to % relative to the No-Pandemic case in The Most Likely scenario suggests a % decline in collections compared to what they would have been had the pandemic not occurred

Table 9: Forecasted Change in Room Taxes in Q4 1 Compared to Expected Room Taxes Under No-Pandemic Scenario in Millions Source: RCG Economics

	Best Case	Most Likely	Worst Case
Nevada	-	-	-
Clark County School District	-	-	-
Local Tourism	-	-	-

### Sales & Use Tax (SUT)

The SUT revenues are estimated to experience hits of % Best Case % Most Likely and % Worst Case in relative to the No-Pandemic case. These would be significant impacts to state and local coffers as the SUT is the largest revenue generator. Additionally, it is possible that enhanced Unemployment Insurance (UI) benefits and the direct pandemic payouts are inflating the model outputs because they no longer benefit households. For this reason, these estimates may be overly optimistic in every scenario.

Table 1 : Forecasted Change in Sales & Use Taxes in Q4 1 Compared to Expected Sales & Use Taxes Under No-Pandemic Scenario in Millions Source: RCG Economics

	Best Case	Most Likely	Worst Case
Nevada	-	-	-
Clark County	-	-	-
Washoe County	-	-	-

### Consolidated Tax (CTX)

The same limitations that exist regarding the SUT apply to the CTX. Even with this possible overestimation, the CTX is still expected to experience declines in of % Best Case % Most Likely and % Worst Case. It makes sense that these drops are greater in magnitude than for the SUT because CTX revenues are largely dependent on spending that is easier to cut out of a household’s budget, like cigarettes and alcoholic beverages.

Table 11: Forecasted Change in Consolidated Taxes in Q4 1 Compared to Expected Consolidated Taxes Under No-Pandemic Scenario in Millions Source: RCG Economics

	Best Case	Most Likely	Worst Case
Nevada	-	-	-
Clark County	-	-	-
Washoe County	-	-	-

### Modified Business Tax (MBT)

The MBT is a state-level payroll tax. With lower levels of employment, it is expected that these revenues would be diminished as well. According to the model results, these declines in relative to the No-Pandemic case would amount to about % in the Best Case % in the Most Likely scenario and % in the Worst Case.

Table 1 : Forecasted Change in Modified Business Tax in Q4 1 Compared to Expected Modified Business Tax Under No-Pandemic Scenario in Millions Source: RCG Economics

	Best Case	Most Likely	Worst Case
Modified Business Tax	-	-	-

## Marijuana Taxes

The Marijuana Taxes the last collections estimated under the model discussed below are expected to take hits similar to those of the MBT by coincidence. In the Best Case we expect a drop of about % compared to the No-Pandemic case. In the Most Likely scenario that drop would be about % percent while in the Worst Case we estimate a % drop.

*Table 13: Forecasted Change in Nevada Marijuana Taxes in Q4 1 Compared to Expected Nevada Marijuana Taxes Under No-Pandemic Scenario in Millions Source: RCG Economics*

	Best Case	Most Likely	Worst Case
Marijuana Tax	-	-	-

## Appendix E: Economic Model Design

Modeling the economic situation relative to the pandemic is a difficult task. First, basic univariate methods are likely to fail because the pandemic presents an economic shift. Second, there are simply not enough data to forecast economic variables analytically in a multivariate model. There are several variables that are helpful to the model, but not enough post-pandemic observations to estimate the variables' coefficients with any certainty. Another complication is that psychological/behavioral and sociological effects are driving much of the response to the pandemic and associated economic outcomes. That makes it even more difficult to measure and predict. For this reason, RCG chose to take a less rigidly statistical approach to modeling economic outcomes relative to the pandemic. The model is based on applying what we think are reasonable assumptions, backed by data and the economic and medical literature, relative to certain drivers that shift a baseline level of GDP. The purpose of this section is to describe these assumptions based on the sources cited throughout the study.

The model that drives the study's results has been performed in a series of steps. The first step defines the scenarios based on certain driver variables. Those variables are driven by assumptions that underlie three scenarios. Next, these variables are used to drive decreases to a baseline GDP forecast that assumes the pandemic never occurred. Finally, the finalized GDP forecast has been used to forecast various indicators of interest.

Based on the information discussed below, three scenarios were created for the Nevada economic forecasts produced in the study, in addition to a hypothetical fourth "no-pandemic" scenario, the baseline GDP forecast. These scenarios should provide a reasonable range of economic outcomes to make more informed decisions relative to the Nevada economy over the course of the next several quarters. The scenarios are:

- No Pandemic
- Best Case
- Most Likely Case
- Worst Case

As the name suggests, the no-pandemic scenario assumes that the pandemic never occurred. The Worst-Case scenario reflects a pessimistic view of the economic effects stemming from COVID-. The Most Likely scenario represents a most likely outcome, based on the research discussed, while the Best-Case scenario presents an optimistic view.

Basing this model on a baseline forecast that assumes that the pandemic did not occur carried the implied assumption that the structure of the post-pandemic economy changed only relative to factors directly caused by the pandemic. This means that if the economy returns to normal today, i.e., COVID- is cured and everybody returns to work, GDP will return to its pre-pandemic level and trend. This may not have been an ideal assumption, but based on the economy's initial bounce back after the lockdown, it appears to be a reasonable assumption over the short term.

The forecast horizon of the study is from approximately Q to Q, depending on when the most recent data have been released for each indicator.

## GDP Model

### No-Pandemic GDP Forecasts

As discussed above to project inflation-adjusted “real” GDP and other indicators into the future RCG required a baseline real GDP forecast for the regional total RCG has produced forecasts by sector as well which is discussed below These baseline forecasts in dollars estimated Nevada’s real GDP assuming the Covid- pandemic had not occurred see Figure III- These have been compared to the actual values of GDP that did occur in This has been done to later apply certain “change” factors to the baselines that arrive at the actual values thus far and then to project those “change” factors to forecast future GDP The model includes natural economic growth because the baseline forecast is in real terms and captured the growth trend in the series since

The GDP data have been obtained from the Bureau of Economic Analysis BEA To produce the baseline GDP forecast RCG has employed the Seasonal Autoregressive Integrated Moving Average SARIMA method A version of the Hyndman-Khandakar algorithm is used to produce initial results and then several variations of the models were then run in order to choose a reasonable set of findings These findings have been double-checked using several visual and analytical tests

### Setting Up Scenarios

After estimating baseline no-pandemic GDP RCG continued estimating GDP under the three scenarios Worst Case Most Likely and Best Case These scenarios have been developed based on the baseline GDP forecasts and three variables:

- Phase effects
- Self-isolation effects
- Unemployment insurance

The discussion below describes how the three factors have been used relative to the No-Pandemic GDP case to produce the results discussed in the previous section It should be noted that there is also uncertainty around public policy options Each potential new future policy will make it more difficult to model the impacts

### Length of Pandemic

Before discussing the three main effects it is necessary to discuss the assumptions regarding the duration of the pandemic We assume that both phasing and self-isolation will end based on the time to widespread vaccination or the time to herd immunity whichever will occur first According to Dr Fauci the economy will not return to normal—as it was before COVID- —until there is a vaccine In terms of time to achieving herd immunity it is too early to estimate when that might happen Based on the studies discussed above there is too much uncertainty in what share of the population has been infected already Additionally the concept of herd immunity may not apply to a novel virus Per Dr Michael Osterholm an epidemiologist at the University of Minnesota it is possible that neither natural disease nor vaccine provide long-term immunity If this were to be the case then COVID- could be around for decades and simply become something that humans must survive However because this possibility lies outside of the time horizon of the study it is not included in the model

According to the New York Times there were over vaccines in development at the end of August However even if a vaccine were ready today it will take time to produce and distribute although pre-purchased vaccines may help speed distribution Wealthy countries will likely horde doses to inoculate their populations before exporting vaccines In the case of the United States

this will speed vaccination relative to poorer nations. Another possible problem is that the global supply chain may not be up to the task of quickly distributing a vaccine worldwide. This could be an issue if U.S. firms are unsuccessful in their efforts to develop a vaccine. Still, in light of these variables, according to USA Today’s pandemic science panel, a vaccine should reach widespread attainability by mid- . However, according to Science, only about % of Americans plan to get the vaccine when it becomes available, with another % still unsure.

Relative to the research discussed in the Worst-Case scenario, RCG has assumed that no vaccine will be discovered before , resulting in a prolonged economic emergency. In the Most Likely scenario, widespread availability of a vaccine in July is assumed. In the Best-Case scenario, availability will occur in April.

### Phase Effects

Phase effects refer to negative modifiers to GDP that will be caused by government-mandated business lockdowns. These lockdowns shutter businesses and effectively halt economic activity. They appear to help limit the spread of COVID-. RCG produced a timeline of the phased lockdowns based on Governor Sisolak’s state of emergency directives. The governor has since stated that he plans on moving away from a “phased” system of lockdowns. However, because the phases in this model have been used as a vehicle to develop a rate of active jobs in Nevada, rather than directly employ the phases as variables, our methodology in this regard should be appropriate.

There have been five official phases of reopening described by the state government. We refer to these phases as: Phase, Phase, Phase, Phase, and Phase, ranging from lockdown to back-to-normal. These phases have been intended to be rolled out based on certain milestones relative to COVID- caseloads. However, the New York Times reported that few states that had planned to lift their lockdowns or had already done so by early May had met the White House guidelines for reopening. Nevada was in this group, as are most states.

RCG uses definitions herein for the lockdown phases’ inactive jobs, by industry, from GOED. This information reflected which sectors’ businesses could remain open during each phase. Phase referred to a total lockdown. Only those businesses deemed “essential” could remain open. RCG employed the GOED definitions to estimate weighted averages for the share of active workers in each two-digit NAICS industry. In Phase, businesses accounting for slightly more than % of workers could remain open. In every successive phase, more businesses will likely be able to open. Phase represented a “normal” economy—no mandated business closures, meaning after the pandemic has ended. Additionally, RCG added a sixth phase to the mix. Through the July Directive, the Governor declared that bars and taverns not licensed to serve food may only offer pick-up and delivery service. RCG assumes that these establishments will not open at all based on this restriction and referred to this altered version of Phase as Phase.

The following explanation provided a sample of the method employed relative to the phasing. In the case of Phase, there will likely be a significant dampening effect on GDP. About % of jobs will be potentially inactive during Phase; this is a lower-bound for the share of active jobs because not all locked down businesses will potentially lay-off all their workers. Research has shown that every one percent decline in GDP correlates to about a one percentage-point increase in the unemployment rate. Assuming that a one percentage-point increase in the unemployment rate roughly corresponds to a one percent decline in nonfarm jobs, there should be a : relationship between percent change in jobs and percent change in GDP. However, because this represents a lower-bound and there is wiggle room in this particular analysis since RCG had to manually estimate

variable effects—an unavoidable drawback to the problem of a lack of data—we applied a % modifier to the % change in jobs to obtain the change in GDP. This has resulted in an approximately eight percent dampening effect relative to the no-pandemic forecasted GDP on days where Nevada was in Phase lockdown. We have repeated this method for each phase and estimated a weighted average of this effect based on the number of days that each phase will potentially be in effect over the course of a quarter.

Following the steps above, RCG designed three scenarios for future phasing to correspond to the model's three scenarios (see Table III). The phase timelines concerning historical data have been produced based on the Governor's directive dates. The three scenario future timelines have been based on research discussed above. Reopening the economy will be an iterative process. In fact, large events such as concerts, nightclubs, bars, and sporting events may not reopen to the public until fall.

In the Worst-Case scenario, it is assumed that infections, hospitalizations, and deaths will surge in the fall through early spring, leading to another Phase lockdown, then reopen to Phase before reverting back to Phase lockdowns in fall, as the scenario assumes no vaccine prior to . In the Most Likely scenario, it is assumed that there will be a minor surge of cases in the fall and winter of , resulting in the state moving back into Phase. The state will likely return to Phase in February. We assume that widespread vaccine availability will occur in July, and with it, a return to Phase. In the Best-Case scenario, it is assumed that the state will move to a Phase reopening in December, with widespread vaccination and Phase following in April.

### Self-Isolation Effects

The second effect included in the model is the "self-isolation" effect. People are generally risk averse, which should lead to an increased propensity to shelter at home for many people, which is independent of government-mandated lockdowns. This self-isolation is most likely to lead to a reduction in spending that negatively affects GDP. In short, lockdowns take away the ability for people to participate in the economy, whereas with self-isolation, people choose to limit their activity in the economy. It is expected that over the course of the pandemic, self-isolation will likely pose the bigger cumulative threat to economic growth.

In calibrating the model, three timelines, one for each scenario, are assumed relative to the effects of self-isolation on the economy (see Table III). These dampening effects represent percentages of lost economic activity starting as of certain dates. For example, relative to the Most Likely scenario, RCG assumes a dampening effect of starting in mid-March. The effect refers to a % decline in GDP relative to the No-Pandemic baseline.

RCG has arrived at a dampening effect of % by trial and error. Based on the phasing effects discussed above and the effects of unemployment benefits discussed below, a % dampening effect due to self-isolation best fit the data relative to Q.

There is a complication that could elongate this downward pressure on the economy. There is evidence suggesting that even if an effective vaccine were to be released in the middle of , many people will decline vaccination. This is likely to cause the pandemic to go on longer than anticipated. A pair of recent polls, one by Pew Research and one by the Associated Press, show that approximately percent of Americans definitely plan on getting vaccinated and about % say that they will probably get vaccinated. That is close to the currently assumed threshold of % that the Mayo Clinic has reported as necessary to stem the spread of the virus. It is very possible that

due to low rates of vaccination the virus continues to spread and to dampen economic growth due to continued self-isolation among vulnerable populations particularly the elderly

Additionally any vaccine created is likely to produce less than % immunity This could limit the severity of the disease but possibly not the spread Dr Drew Weissman of the University of Pennsylvania told Fortune that “if the best COVID- vaccine is only percent effective that’s still to me a great vaccine ” While a %-effective vaccine will do much to stem COVID- the continuing transmission will likely lead to a lengthening in people’s fear of the virus and therefore a longer-lasting propensity to self-isolate

Based on the above in the Worst-Case scenario RCG assumes a % hit to GDP through September then rising to % in the fall and lasting throughout the forecast horizon in this scenario In the Most Likely scenario we assume that this effect decreased to % in April but will then increase to percent in October before returning to % in the spring It will then decline to five percent with the introduction of the vaccine in July through the remainder of the year In the Best-Case scenario RCG assumes that the self-isolation effect decreased to five percent in April and will go to one percent in July through the end of

In general in the Worst-Case scenario RCG assumes that self-isolation will increase due to heightened fears of venturing outside caused by hypothetically increased deaths in the fall In the Most Likely scenario RCG assumes a slight increase in self-isolation in the fall and winter due to a modest increase in deaths but then returning to Summer levels We also assume that some propensities to self-isolate will remain after widespread distribution of a vaccine because polls show that many people are not planning vaccinations right away This will likely lead to lingering infections and therefore fear of infection In the Best-Case scenario we assume a small amount of lingering fear starting in the summer due to only small levels of continuing transmission of COVID- following an April vaccine

### Unemployment Insurance

The third major variable in the model is unemployment insurance With the large number of unemployed workers in the state a significant portion of personal income comes from these payments There are two components: state UI and federal UI The federal UI is meant to enhance state UI benefits and hold households over during the pandemic

To estimate these funds RCG has collected data from the Nevada Department of Employment Training and Rehabilitation DETR on the number of unemployment claims as well as the payment amounts RCG then made various assumptions about the number of unemployed persons that will be receiving these benefits as well as the amounts they are likely to receive through the end of

We assume there will be no change to the weekly historical claim payment which was per week in July Again there are three scenarios describing these outcomes All dollar amounts are in dollars to match our GDP forecast

First RCG developed assumptions relative to the number of unemployed persons collecting UI benefits Generally we assume that the number of those receiving benefits will remain at the levels of the most current data about claims per month in the state This will continue until widespread distribution of a vaccine at which time people should start finding employment again This assumes that the labor market is in steady state as of July Then because all of these levels are relative to a baseline GDP it is necessary to subtract the standard unemployment benefits that will occur in normal times We then assume that the number of those accepting UI benefits will decline linearly until reaching the levels estimated for the end of in the three scenarios see

Table III- This assumes that the number of workers at the end of controls in part for the speed of the recovery We also have assumed that people will go back to work when called in or upon finding a new job which should happen in a timely manner despite receiving UI benefits

For the Worst-Case scenario because RCG assumes that there will be no vaccine available before the end of total persons receiving UI benefits remained at their August level throughout the forecast horizon In the Most Likely scenario RCG assumes total UI claims will drop to average monthly claimants by the end of This assumes that the state will regain about two-thirds of its jobs relative to August equivalent to approximately an eight or nine percent unemployment rate In the Best Case we assume that unemployment claims will return to monthly claimants approximately their pre-recession levels

Relative to the amount of the UI benefits RCG assumes that the state UI benefits will remain unchanged compared to what they had been in July For the federal enhanced UI benefits which may have started for some as early as late March RCG used a different set of assumptions for each scenario see Table III- In the Worst Case we assume that gridlock in Washington D C will continue to keep new enhanced benefits from taking effect Recent reports indicate that lawmakers may strike a deal in September or that they may not do so until the next Congress begins To account for this uncertainty RCG assumes a - split in the chances of each possibility and picked a date in the middle We have also assumed that these enhanced funds will decrease to per week in January with benefits coming to an end in June In the Best-Case scenario we have assumed that enhanced benefits will resume at per week on September declining to per week in January and continuing through the end of

Those UI benefits should also continue to benefit the economy through the “multiplier effect ” which accounts for future spending of those same monies To account for this effect we applied a multiplier of based on household-spending-induced effects in the most recent IMPLAN input-output model for Clark County

### Model Limitations

The purpose of the model is to capture the major outcomes of various behaviors and policies to produce reasonable estimates of GDP through RCG believes that the model is successful in this respect However there are factors at play that are only implicitly included or in some cases left out altogether

One major limitation of this model is discussed above Because there are not enough data available RCG estimates the outcomes of the model manually At the time of writing there is only one state-level data point collected relative to the pandemic Therefore there is more than one solution to the hypothetical econometric formula estimated

In the case of federal stimulus stemming from the CARES Act some policies are included implicitly while others have explicitly not been included For example RCG did not include the direct individual stimulus Data on the personal saving rate show that saving in April spiked to an unprecedented % This suggests that households are aware of the possibility of dire financial outcomes over the course of the pandemic and are putting aside funds to hold them over if necessary In fact a recent Forbes analysis has found that as much as % of households are saving all the funds they received from the one-time payment Money saved today is money spent tomorrow so to speak Therefore because RCG assumes that all UI benefits will be spent immediately we chose to be conservative with respect to the stimulus checks and assume that none of it will be immediately spent We think this is a reasonable assumption because in our Most Likely

and Best-Case scenarios. UI funds amount to far more than the stimulus checks and there is still so little information available about how all of these funds have been used. This assumption linking UI to the stimulus should offset changes in the saving rate.

In the case of the Paycheck Protection Program “PPP” —a program that dispenses loans meant to incentivize small businesses to keep their workers —those funds have not been included in the model explicitly. However, because RCG used assumptions relative to the number of unemployed workers in the model, we did make implicit assumptions regarding the program.

There are several other provisions in the CARES Act. However, we assume that they will have relatively little effect on GDP. Furthermore, by definition, business-to-business transactions do not directly affect GDP. Of course, these transactions do affect GDP indirectly. Still, we assume that there will be no major disruptions to business aside from those related to the pandemic.

Another limitation stemmed from lag effects caused by the economic crisis. For example, as spending declines, future revenues to the state and municipalities should decline as well. The secondary effects of these declines on future GDP is difficult to estimate in terms of both magnitude and timing and have not been included in the model.

The final major limitation is tourism, a major component of the Nevada economy, particularly Southern Nevada. The Great Recession showed that tourism demand in Las Vegas lags economic growth nationwide, especially relative to California. Economic research suggests that is generally true for North America. This lag effect is not included in the model explicitly, though it is considered relative to the model’s final UI claim levels in Q

### GDP Forecast Results

As of this August, there was only one data point for state-level GDP available that included the pandemic with which to calibrate our model. For this reason, we have been able to obtain an estimate within a fraction of a percent of the actual Q GDP estimate for Nevada. However, because our methodology is straightforward and contains two scenarios capturing the most extreme outcomes as well as a most likely scenario, we believe that the results provided herein represent a reasonable set of outcomes for Nevada GDP through . Nevertheless, as more data come in, RCG could revisit the underlying assumptions and update the forecast. The Q state-level GDP data are scheduled for release in early October.

### Indicator Models

In addition to the forecast of real GDP, RCG has also produced projections for a set of economic and fiscal indicators for Nevada, the Las Vegas Metropolitan Statistical Area (MSA), and the Reno-Sparks MSA. In this section, RCG describes the data and methodology used to develop these additional forecasts. A number of metrics were used to develop these forecasts, including tax collection and unemployment statistics, among others. A full list of the used metrics and their corresponding geographic availability, i.e., state, local, or jurisdictional, is available in Appendix A.

RCG has employed a single method to forecast the indicators to maintain conformity and consistency across the measures. RCG used the ARIMA with Exogenous Input “ARIMAX” model. This model forecasts an indicator based on its relationship with outside variables. In this case, RCG has used real GDP, as forecasted above, as the exogenous input. We expect GDP to be a good explanatory variable because GDP is generally a function of various economic indicators. Therefore, it should move together with or inversely relative to those indicators. The model enables us to measure how

real GDP moves with each of the Indicators in the past and then uses the real GDP forecast above to predict how the indicators should change over the forecast horizon

In terms of the dates that have been analyzed and forecasted a difference between this analysis and the above GDP forecast is that RCG forecasts the series starting with the most recent historical data rather than the last data point to improve forecasting results i.e. fewer forecasted data points lead to more precision and accuracy

A limitation of this model is that in certain cases because of the extreme circumstances of the pandemic economic data have been outside of typical ranges. With no historical data on these types of swings the model may overweight or underweight these swings in some cases. However this situation is unavoidable regardless of the model type and furthermore RCG is comfortable that the results are generally reasonable. A second limitation that at times can compound with the previous limitation is that because RCG used a single indicator as the exogenous input the results of certain forecasts might not necessarily match the original assumptions

Rather than run the model on each geographic subset RCG has run the model on total Nevada revenues and uses the average share of the subsets relative to the state data since to calculate those series' values. This is reasonable to do because the shares do not change significantly over that time frame. For each indicator we have produced results for the same four scenarios as for GDP. Data for the model have been aggregated annually for all tax indicators and quarterly for all economic indicators. GDP sector results have been reported in dollars. All other monies are reported on a nominal non-inflation adjusted basis.

The data for the indicators come from various sources. RCG has identified and used the sources that show the most complete accounting of each tax even if those sources provide less detailed information at the sub-state level. We have done this to get the best estimates of total collections. State totals generally reflect total collections in the state rather than the state's share of a tax. All tax results are presented in fiscal years while economic indicators are presented as quarterly.

Monthly data on employment and unemployment came from the Bureau of Labor Statistics

Visitor data herein are sourced from the visitor and convention authorities of the Las Vegas and Reno-Sparks areas. We combined these to represent Nevada visitors. These monthly data do not account for total Nevada visitation but cover about percent. Data for Nevada visitation had not been updated in nearly a year and the Nevada Department of Tourism and Cultural Affairs has suggested basing our estimates on these updated regional aggregates.

RCG has also collected data on the Property Tax also referred to as the "Ad Valorem Tax" and Room Tax from the Nevada Legislative Counsel Bureau "NLCB". The NLCB does not break down collections by geography. Instead they show allocations to the major revenue recipients aggregated by type so in the case of the Property Tax: Nevada and Local Government & School Districts. For the Room Tax the breakdown includes Nevada Local Tourism and CCSD.

Another tax series that has been collected is the Gaming Tax. Those annual data come from the Nevada Gaming Control Board and cover the state and largest counties. The data include gaming properties with annual revenues of at least million so it does not capture all of the tax revenues but it does capture approximately percent.

Taxable sales monthly modified business tax revenue quarterly marijuana taxes revenues monthly SUT monthly and CTX monthly data come from the Nevada Department of Taxation. Results are presented annually. Due to the way that many of these revenue sources are collected

and distributed it is not feasible to separate them all by county. However, RCG has separated them locally to the extent practical. For taxable sales, we have produced forecasts for Clark and Washoe counties in addition to the state. The modified business tax “MBT” is collected by the state and put into the state’s general fund. Therefore, while counties and municipalities benefit, they do so based on the many formulas that are used to distribute those funds. Regarding marijuana revenues derived from a retail excise tax and a wholesale excise tax, we have performed an analysis at the state level only. Sub-state data have only been published for one year at the time of writing and it is not feasible to run an analysis on so few data, particularly when there are not enough data to perform the state-level analysis, as discussed above.

The SUT and CTX data are provided herein for each county as well as the state. RCG has analyzed these for Nevada, Clark County and Washoe County. Both taxes are comprised of several components. The SUT includes the state sales tax, the Local School Support Tax “LSST”, Supplemental City-County Relief Tax “SCCRT”, Basic City-County Relief Tax “BCCRT”, and county-level option taxes. The CTX is comprised of the Liquor Tax, Cigarette Tax, Real Property Transfer Tax “RPTT”, and Government Services Tax “GST”. RCG has summed the various taxes together for each geography to obtain the totals for the two taxes at each level. As a note, RPTT data are not broken down by county, so the county-level results do not include that tax. Certain SUTs are reported with CTX data. Those had to be separated. These data have been obtained from the Nevada Department of Taxation’s “Taxation”, “Statistical”, and “Consolidated Tax” reports and aggregated by fiscal year and region.

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# **STANDARD PLANS FOR A SMALL ABATTOIR AND MEAT MARKET**

## **SECTION 1**

### **BACKGROUND**

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### **STANDARD PLANS FOR A SMALL ABATTOIR AND MEAT MARKET**

#### **SECTION 1 : BACKGROUND**

## **1.1 INTRODUCTION**

This report presents designs, specifications, and schedule of quantities for an abattoir and meat market suitable for small communities in the South Pacific region. The design could however be utilized by small communities in other developing countries, although some modifications to suit changed local conditions may be required.

Provision is made in the basic design for slaughter of all species, viz. cattle (or buffalo), sheep, goats and pigs though because of space limitations, concurrent slaughter of different species is not possible. The abattoir capacity will be dependent on the mix of animals being slaughtered. Daily throughputs of approximately 5 large stock (eg cattle) or 50 small stock (sheep, goats or pigs) or a combination thereof represent a practical maximum for this design.

## **1.2 BASIS OF DESIGN**

The design has been based on “Guidelines on Small Slaughterhouses and Meat Hygiene for Developing Countries” WHO publication VPH 83.56, with modifications to take account of the likely mix of stock in South Pacific countries.

## **1.3 FACILITIES**

The facilities are divided into a series of ‘modules’ which can be combined as required to suit a particular location.

The following modules are included:

- a. Production Modules
  - i. Slaughter floor
  - ii. Lairage
  - iii. Chiller
  - iv. Tripe room
  - v. Meat cutting and processing
- b. Service Modules
  - i. Water supply
  - ii. Effluent disposal
  - iii. Solid waste and blood disposal
  - iv. Hide and skin processing
  - v. Electric light and power

### c. Meat Market

These modules and the options available within the individual modules are described in Section 1.5

A possible overall abattoir layout based on the above modules is shown in Drawing 1.

This layout shows a typical arrangement for a facility designed to handle beef, small ruminants and pigs with the main emphasis placed on small stock. Modifications for a larger beef kill and/or the elimination of pig slaughter (eg for Muslim communities) are possible.

### Exclusions

The following items which are necessary to the functioning of the abattoir have not been detailed in these standard plans.

- a. Amenities and Office
- b. Fencing
- c. Rooding
- d. Stormwater drainage
- e. Planting to effluent trenches

These should be provided in accordance with local practice based on locally available materials.

## **1.4 LOCATION AND SITE**

A minimum site area of 1800 square metres will be required to accommodate all modules. The abattoir layout presented is based on a rectangular site 30 metres by 60 metres.

Only general guidance as to location and siting can be given in a report such as this. Points to consider in selecting a suitable site are listed below. In practice compromises will inevitably be needed when selecting a site.

In presenting this check list it has been assumed that a general locality for the abattoir will already have been established based on sources of stock supply, location of markets, and taking into account transport methods and infrastructure availability.

### a. Distance from Urban Development

The abattoir should not be located close to dwellings, schools, churches and other public or commercial buildings due to possible nuisance from noise, smell congestion etc. Likely future commercial and residential developments should also be taken into account.

### b. Accessibility

The site should be accessible from a permanent road to allow ready transport of both livestock and meat.

### c. Water Supply

An adequate water supply is essential. While mains water is to be preferred, well or bore water will also be suitable provided the water meets drinking water standards.

Quantities of 1000 litres per large animal 100 litres per small ruminant 450 litres per pig are desirable.<sup>1</sup>

In some areas it may be necessary to rely on rainwater collected from the abattoir roofs. (Under these circumstances water usage will need to be much lower than given above and 'dry' slaughter systems should be adopted.<sup>2</sup> The use of rainwater should however be avoided if at all possible due to the limited supply available from this source.

<sup>1</sup> Refer "FAO Design of Model Slaughterhouses for Rural Areas" Section 2.4

<sup>2</sup> Refer WHO VPH/83.56 Section 5.5

#### d. Effluent Disposal

The effluent disposal schemes presented in this report are based on subsurface irrigation and soakage. Such systems are generally lower in cost and easier to operate than other alternatives. The site should therefore be free draining and not subject to waterlogging or flooding. Land used for subsurface irrigation need not necessarily be within the abattoir boundary although control over cropping operations above subsurface irrigation trenches would be essential.

#### e. Foundation Conditions

Section 2.2 details foundation conditions required for the buildings together with details of simple tests for suitability.

#### f. Solid Waste Disposal

There should be sufficient space available to bury inedible wastes and condemned animals and provide for compost stacks, hide drying frames etc.

#### g. Electricity

Connection to a public electricity supply is desirable especially if chilling of carcasses is being considered or on site water pumping is required.

## 1.5 DESCRIPTION OF MODULES

### 1.5.1 Slaughter Floor

The slaughter floor layout is shown on Drawing 2. The designs assume procedures for slaughter of each species as follows:

#### a. Cattle

The animal is led into the bleeding area where it is restrained by a tether through the floor ring prior to stunning (using a captive bolt pistol). After stunning the animal is shackled by one leg and hoisted, with a rope pulley block. The animal is then stuck and allowed to bleed in this position and the blood collected in a drum for disposal.

Once bleeding is complete the head can be removed and the animal lowered onto the cradle for dressing. The feet are then removed, the skin opened up along the breastbone and the hide partially flayed. Leg hooks are then attached and the carcass raised to a 'half-hoist' position on the spreader. Flaying can then be completed and the hide removed. The paunch can then be removed to the inspection buggy and the red offals (including lungs if treated as edible) placed on hooks or the inspection table for inspection.

After inspection the carcass can be split and quartered, the quarters being individually hung on the low rail.

Once the carcass has been partially flayed and half-hoisted a second animal can enter the bleeding area.

#### b. Pigs

Pigs are first stunned in the stunning area then hoisted for sticking and bleeding and then transferred to the scald tank. After scalding for approximately five minutes at 60°C the carcass is removed to the scraping table. After scraping a gambrel can be inserted into the hind legs and the carcass transferred to the overhead rail for final scraping and evisceration. Once a pig is clear of the scraping table the next pig can be placed in the scalding tub.

#### c. Sheep and Goats

These would be slaughtered and dressed on the rail in the pig area in a similar manner to pigs. The scraping table is removed to one side during processing of sheep and goats.

### 1.5.2 Lairage

Generally the lairage should be sized to hold the expected daily kill. This will allow stock to be held overnight before slaughter. In some special cases a greater capacity may be required although the holding of stock at the abattoir for an extended period before slaughter should not be permitted.

Lairage areas for each specific abattoir should therefore be assessed relative to expected throughput. Pen areas required for each species are as follows;

<b><u>Species</u></b>	<b><u>Area</u></b>
Cattle	1.7m <sup>2</sup> /head
Pigs/Sheep	.35m <sup>2</sup> /head
Goats	.25m <sup>2</sup> /head

The lairage shown in the model has been sized to accommodate 4 cattle in two pens of 2 each and 28 pigs or sheep in four pens of 7 each. Alternatively up to 40 goats could be held in the small stock pens or a mix of the two species held. A single pen for isolating sick or suspect animals is also shown. Unloading facilities for trucks have not been shown as in many cases these will be unnecessary. If required these should be designed locally.

In localities where animals, particularly cattle, are normally tethered, a larger area without dividing fences may be preferred to allow tethering rather than penning of animals.

### 1.5.3 Chiller

The chiller shown is a proprietary module with a holding capacity of approximately 300kg and a chilling capacity of 150kg/day. In this size range the use of a prefabricated unit has the advantage that complete assembly and testing before leaving the factory is possible. Also a factory built and tested unit will generally be the lowest in cost as skilled on site work is minimised.

### 1.5.4 Inedibles/Condemned Material

For a plant of the size described here the operation of a by-products plant would not be economic.

Two possible methods of disposal suitable for a plant of this capacity are:

- a. incineration
- b. disposal in a pit (recommended option).

#### Incineration

A simple incinerator could be constructed from a used oil drum as described in VPH/83.56.<sup>1</sup> In practice however such incinerators are difficult to operate and require substantial quantities of fuel to ensure adequate destruction of meat and offals. Incineration is therefore not recommended.

#### Disposal Pit

The preferred alternative, a disposal pit, is simple to use and once constructed costs nothing to operate. Most of the material placed in the pit will slowly decompose, and for an abattoir of the size described, such a pit will be usable for many years. A suitable pit is detailed in Drawing 12. Construction will however need to take into account ground conditions particularly the ground water level (the pit should not extend below the normal water table). In suitable ground conditions it may be possible to dispense with the lining to the lower portion of the pit. It is particularly important that rain water does not enter the pit hence the walls of the top section of the pit should be solid as shown in the drawing.

### 1.5.5 Ruminal Contents

Particularly in the case of cattle a considerable quantity of ruminal contents has to be disposed of. A compost stack provides a simple and low cost method of disposal as well as providing a useful end product. Dung from the pens, effluent screenings and other wastes may be conveniently disposed of in this way. The addition of waste vegetable material such as maize and cassava stalks, straw etc. will

increase the yield of compost and ensure aeration of the stack. A full description of the operation of a compost stack is given in VPH 83.56.<sup>1</sup>

For the smallest plants a simple compost stack will be adequate, but for larger throughputs, and particularly when a significant number of cattle are to be slaughtered, a permanent compost bunker should be provided as described in VPH 83.56.

<sup>1/</sup> Guidelines on Small Slaughterhouses and Meat Hygiene for Developing Countries W.H.O. 1984, page 98.

### 1.5.6 Blood

Blood is a valuable source of protein. However at this scale a by-products plant to produce blood meal could not be viable. Blood should not however be diverted into the effluent system since it will quickly clog up the screens and disposal trenches.

By using the following treatments blood can be incorporated into stockfeed. It must be stressed that even if the treated blood must be given away this is still preferable to disposal of blood on site. (In the event that blood cannot be disposed of as stockfood a separate blood sump, similar to the solids pit could be constructed adjacent to the slaughterboard. But only as a last resort).

Alternative methods of treatment are;

#### a. Fresh Blood

Where pigs and poultry are kept nearby, fresh blood can be directly incorporated into bran, cassava or other stock food. This represents the simplest and most efficient means of disposal. With this method it is essential that the resulting meal be fed out the same day as it has no keeping properties.

#### b. Lime Treated Blood

Where a somewhat longer life for the feed is required approximately 1 % of unslaked (burnt) lime can be added to the blood container and stirred in as the fresh blood is added. The hardened product will keep for up to one week. It should be used as described for fresh blood.

#### c. Dried Blood

Where it is not possible to directly add fresh blood to pig or poultry feed, it may be mixed with bran or cassava as described under (a) and dried in the sun, on either a concrete floor, or matting. Drying will generally be complete in three days. (The drying area will need to be covered in the event of rain). During rainy periods it would be necessary to dry the mixture on corrugated iron trays placed over a copra dryer or similar fire. Because of the additional cost of drying this method is only recommended where the methods described above cannot be used. Since all the methods described above for blood disposal use readily available local materials, construction details have not been provided in this report.

### 1.5.7 Hides and Skins

Three alternatives exist for the disposal of hides and skins:

- a. Burial
- b. Drying and sale
- c. Salting and sale.

The quantity and quality of hides and skins will determine whether or not it is worth saving and marketing the hides and skins produced. Where there is only a small cattle and goat kill the costs of preparing hides for sale may well outweigh the returns. In these cases the hides should be disposed of by burial.

Each case will need to be assessed individually however as a general guide the export of less than 100 cattle or 500 goat skins per annum is unlikely to be economic.

For most abattoirs built to this design this means that exporting will only be economic if hides and skins can be marketed in conjunction with those from other abattoirs.

Other factors that would lead to the selection of burial include:

- a. Pre-slaughter damage apparent in most animals
- b. High shipping costs.

Whenever expected returns outweigh costs hides and skins should always be processed for sale. For a single abattoir drying is recommended. Salting should be considered only when production reaches the equivalent of 30 cattle hides per week. This would necessitate the combining of production from several abattoirs and is not discussed further here<sup>1</sup>.

<sup>1</sup> Refer Mann 'Processing and Utilization of Animal By Products' FAO, Rome for further detail of salting methods.

## Drying

For abattoirs of this size suspension drying is recommended. Suspension drying can be carried out using locally made equipment and needs no other materials. Where throughput permits a simple a roofed area should be provided for washing and fleshing hides prior to stretching on drying frames. Drying frames for cattle hides should be approximately 3 metres square and can be made of bamboo or small round timbers lashed together at the corners as shown on drawing 18.

### 1.5.8 Effluent

For a plant of this size two options for effluent disposal are practical.

- a. Subsurface irrigation
- b. Soakage pits

Generally subsurface irrigation is to be preferred although where soil conditions are suitable the use of soakage pits may be simpler.

The discharge of effluent into water courses or other existing bodies of water is not recommended as this will lead to pollution. Effective waste water treatment, at this scale prior to discharge into water courses is generally impractical and certainly will be more costly than the simple methods of disposal outlined above.

#### Subsurface Irrigation

This system is shown on the drawings. Planting of banana palms or paw paw should be made along the trenches to utilize the moisture and nutrients contained in the effluent. Root crops such as taro and cassava should not be planted over the trenches. It is possible only to give general guidance as to trench lengths required. One twenty five metre long trench as shown should however prove adequate in most cases.

Provision for a second trench is shown on the layout. If desired the irrigation trenches could be constructed outside the boundary fence so that crop management becomes the responsibility of an adjoining landowner. Root crops should not be grown over the trenches.

#### Soakage Pits

Where soil conditions are suitable (i.e. free draining) soakage pits may be used in place of irrigation trenches. No details of construction are presented here. However the importance of adequately covering any soakage pit must be emphasised. It should also be realised that even if wastes are efficiently screened, soakage pits will block up with time. Provision should therefore be made to dig additional pits in the future as the rate of soakage declines.

### 1.5.9 Stormwater

No details for stormwater collection and disposal have been shown on the drawings. Provision will have to be made to dispose of rain water from roofs and paved areas. The most appropriate means of

disposal can only be considered once a site has been selected. Local practise should be followed.

### 1.5.10 Water Supply

The importance of a supply of clean potable water cannot be over-emphasised. The plans presented assume connection to a town main or pumped well supply. Hot water for washing has been piped to a single point in the abattoir only. While this will require the use of buckets and brushes for cleaning equipment this system does conserve water. Also cleaning in this manner is more effective than using low pressure hot water hoses.

Roof gutters have not been detailed. In areas where a piped water supply is not available roof gutters should be included and water collected into a tank located as shown on Drawing 1. Where tank water only is used provision of an electric pump is most desirable.

## 1.6 ALTERNATIVE ENERGY SOURCES

While a wide range of alternative energy sources have been discussed in the literature only a limited range of alternative energy sources are likely to be of interest in most abattoir situations.

When considering using alternative energy sources it must be borne in mind that the primary purpose of the abattoir is to provide hygienic facilities for animal slaughter and dressing; the incorporation of alternative energy sources should not require a large degree of management input. For this reason only alternative energy sources with a proven history in the area should be considered for installation in the abattoir.

For this reason, and because of widely varying costs of energy from conventional sources, each abattoir site will require individual consideration.

### 1.6.1 Biogas

With the availability on site of raw material in the form of animal wastes and the requirement for hot water for processing, the generation of biogas should be considered.

It is not possible to give hard and fast rules for considering installation of biogas plants however the following guidelines list those items for and against installation.

#### FOR

1. Relatively large throughput, relatively constant both over the week and annually, (over 5 large stock per day or equivalent).
2. Previous history of successful biogas plants in the locality.
3. Shortage of low cost solid fuel for the boiler.
4. High cost of alternative fuels.
5. High pig kill (pig excreta yields more gas than cattle or sheep).

#### AGAINST

1. Intermittent killing pattern, large kills one or two days a week.
2. Low cost fuel available.
3. No other biogas plants in the area.

### 1.6.2 Solar Heating

Simple solar water heating panels unfortunately, cannot produce water temperatures required for pig scalding (60-65°C) thus supplementary heating is required. Also in many regions solar heat may not be available for significant periods. Because of this investment costs are inevitably high for heating systems

incorporating solar panels and are likely to render such systems uneconomic except where fuel costs are very high. In these circumstances it is a direct competitor with biogas.

Where pigs are not slaughtered solar panels could however be used to provide warm water for amenities and for washing in the abattoir.

### 1.6.3 Solar Lighting

Where electric power is not available and early morning slaughter practised the use of solar cells in conjunction with storage batteries and low voltage fluorescent lamps should be considered. Standard systems are now available from several suppliers and would be very effective under these conditions.

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# Around Carson

*Life in and around Carson City, Nevada*

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☰ Menu

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JANUARY 4, 2006 BY SCOTT SCHRANTZ

## The 2005 Flood

It looks like I missed all the excitement! I flew out of town on Christmas Day, and then last weekend from the comfort of my hotel in downtown Seattle I started hearing about flooding in Carson City, mudslides coming down from the hills, road closures, and all kinds of other things that made me glad I scheduled my vacation when I did. And then we arrived back in town Monday night to find this muddy, swampy mess, all covered with a fresh layer of ice and snow. So what really happened while I was away? He's what I pieced together from reading the newspaper:

Late last week, a winter storm brought snow to the mountains and rain to the valley. Unlike our usual storms, which come in for a few hours and then move on, this one wasn't going anywhere. It rained all day Friday, and by Saturday the rivers and streams were beginning to fill up. Carson City [was placed under flood watch](#).

Saturday apparently was the [worst day](#). The Carson River had risen above its flood stage, sending water [through the golf course](#) in Gardnerville and [closing Hwy 395](#) at Cradlebaugh Bridge. Muller and Genoa Lanes were closed because the river was

flowing over the pavement. Loose soil and dead trees from the Waterfall Fire [washed down the mountains](#) outside Carson City, bringing a flow of mud and logs that clogged the storm drains and flowed down city streets. Residents everywhere were [piling up sandbags](#) to keep the water out. Carson's roads flooded, causing some cars to stall out and even float away. For a while it looked like we might have a repeat of the 1997 New Year's Flood, where the waters just kept coming and most of Carson City and the Carson Valley were shut down for days. But, late on Saturday, the storm slowed down and the waters started subsiding. The worst was over.



Sunday was the dawn of a new year, and also a [day of cleaning](#) for Carson City. Snowplows were put to work clearing the streets of mud. Free sandbags were

available for the taking for anyone who was still working to keep the water away. Prison inmates were put to work all over the state, filling sandbags and fixing and clearing roads. Businesses dealt with cleaning up and trying to reopen. And although the storm had subsided, rumors of a second wave of moisture were floating around. It looked like Mother Nature wasn't done with us yet.





And indeed she wasn't. On Monday it [started snowing](#), covering all the mud and still-standing water all over town with a thick blanket of 4 to 6 inches of snow. Snowplows that had been pushing mud around were now back to pushing snow. And as the white stuff fell, it hid the true impact of what had happened over the weekend. Muddy roads started to become a pristine white. Areas of standing flood water became icy ponds. Carson City started to look like it did after any normal winter storm.



But even though Mother Nature is trying to hide it, we still know it's there. Underneath all that snow is a [layer of mud](#) that needs to be cleaned up. There are flood waters that need to recede. There are damaged roads, like Hwy 342 to Gold Hill that [collapsed into a sinkhole](#), and Six Mile Canyon between Dayton and VC which was so undermined by the storm that it will remain [closed for months](#). The governor has declared several counties to be disaster areas, and we've got a lot of work to do to get back to normal.



But, it could have been a lot worse. Anyone who was here in 1997 knows that. And anyone who wasn't in the area for that flood should ask someone who was. So we got off pretty easy this time.

But now I want to hear your stories. I want to see your pictures. Ryan Jerz has already posted [a video](#) and some [Flickr photos](#) showing what the Truckee River in downtown Reno looked like on Saturday. Now I want to hear from the rest of you, the ones who, unlike me, actually had to live through Saturday's flooding. Post in my comments. E-mail me pictures, or [post them yourself](#). Or put something on your own website and send it to me. I know that what I read in the newspaper is only the smallest sliver of what really happened out there. I want to hear more, and I'm sure everyone else does too. Time to share!

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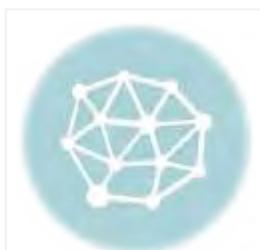
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# “America’s Slaughterhouse Mess”

by [Baylen J. Linnekin](#)  
05.02.2017, 12:08pm

Opinion

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When Americans grumble about how our food system is broken, the slaughter and processing of farm animals are often at the heart of their critiques. One hundred years ago, Upton Sinclair’s damning novel, *The Jungle*, exposed many gruesome and unsanitary practices in the food system of his day. A host of important federal food-safety regulations, including mandatory inspections, soon followed.

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This is an excerpt from [Biting the Hands That Feed Us: How Fewer, Smarter Laws Would Make Our Food System More Sustainable](#) (September, 2016) by Baylen J. Linnekin.

But that was hardly the end of the story. Instead, attention to livestock slaughter has only grown in recent years. In 2014, for example, I moderated a panel at Harvard Law School on sustainable meat

production as part of a conference called “The Meat We Eat.” The conference was cosponsored by two Harvard Law student groups—the Food Law Society, the first of many similar student groups that have popped up at law schools around the country in recent years, and the Student Animal Legal Defense Fund. The title of my panel—“Reducing Legal Barriers, Empowering Consumers, and Creating Pathways for Sustainably and Humanely Raised Meat”—nicely encapsulates the obstacles that many farmers, consumers, and others face in their efforts to sell, buy, and eat the type of meat they want. Many of these obstacles are the result of a mandatory food-safety inspection system, administered by the USDA, that is deeply flawed.



Island Press

Today’s USDA food-safety rules require that agency inspectors be present at a facility every day that meat is processed. In 2007, though, stunning reports emerged that USDA inspectors had failed to inspect hundreds of plants regularly, as required, for [thirty years](#). Although the agency’s failure to inspect hundreds of facilities regularly for three decades is outrageous, even that fact doesn’t illustrate the broken state of the agency’s food-safety rules quite as

well as does the closure of a Petaluma, California slaughterhouse in 2014. That year, the USDA suddenly forced Rancho Feeding Corporation—the only USDA-approved slaughterhouse in Northern California—to close. An agency investigation indicated the facility had illegally processed cattle that were [suffering from cancer](#).

The presence of cancerous meat led the USDA to order the recall of 8.7 million pounds of beef processed by Rancho. The agency was clearly justified in taking any cancerous meat—which was disgusting at best and which could pose food-safety problems at worst—out of the food supply. By also ordering the recall of millions of pounds of beef that was entirely wholesome, though, the agency was throwing out the baby with the bathwater. Worse still, as I'll explain, the USDA's own food-safety rules were largely to blame for the agency's decision to order the destruction of perfectly good meat.

## **USDA rules often force small, sustainable farmers to ship animals hundreds of miles away—even out of state—to be slaughtered.**

One morning in 2009, when I was living in Fayetteville, Arkansas, where I was studying agricultural and food law, I jogged by a pair of cattle dining on grass in a fenced pasture a couple blocks from my apartment. As I slowed down to take a look at them, I noticed some flyers attached to the fencing along the roadside. I stopped running and grabbed a flyer. Sure enough, these cattle or parts of them, at least— would soon be for sale in fifty-pound boxes. After I finished my jog, I called the phone number on the flyers. Another phone call, a few emails, and a week or two later, I was the proud owner of a box of steaks and other cuts raised by Tommy Daniel, a recently retired professor of crop, soil, and environmental sciences at the University of Arkansas.

You'd think that these cattle, raised lovingly and openly in a pasture a block from the main intersection in a college town, might be spared the indignity of enduring a road trip to meet their end at a far-off processing plant. They'd be killed locally and sold to people like me. You'd be wrong. Though Prof. Daniel's cows lived out their days in a pasture only

two blocks from my home, that fact hides the journey they—and animals like them around the country—face if they're to become dinner. Prof. Daniel had to send his cows *only* sixty miles to be slaughtered. Other farmers—and their livestock—aren't so lucky. USDA rules often force small, sustainable farmers to ship animals hundreds of miles away—even out of state—to be slaughtered and processed alongside animals that were raised without the same care. That's because USDA rules unnaturally amalgamate animals from farmers and ranchers of all types and sizes—from cattle raised on the smallest grass-fed beef farm to those raised on the nation's largest confined animal feeding operations (CAFOs)—into many of the same USDA-approved slaughterhouses. This is largely true because rules are uncaring, and because there simply aren't enough slaughterhouses to meet demand.

**“When I take my animals to be processed, I drive past a custom facility three miles from my house and travel three hours to a USDA facility.”**

There are more than 800 federally inspected slaughterhouses in the United States, according to recent USDA data. Another 1,800 are operated by states or are “custom” slaughterhouses—where sales are severely restricted to prohibit, for example, sales to grocers. But figures showing a proliferation of custom slaughterhouses are misleading. The thirteen largest U.S. cattle slaughterhouses account for 56 percent of all cattle killed in this country. The figures are similar for hogs (twelve plants account for 57 percent of all slaughters) and other livestock. Commercial plants processed [47.3 billion pounds](#) of red meat (including cattle, pork, sheep, and other hooved animals) in 2014.

USDA requirements for slaughterhouses the agency inspects are part of the problem. They're so complex that the agency itself funded a [report](#) in 2012 for the purpose of establishing “a streamlined regulatory proposal that could be carried forward in future years to make the USDA inspection system less onerous to smaller facilities that could perceivably be built or utilized in more small local communities.” That sounds great. But the report writers concluded that their mission was damn near futile. “After the numerous conversations and meetings, it became

apparent that no one with the USDA or . . . working as professionals within the meat industry,” they write, “believe[s] that streamlining regulations will ever occur.”

## **On-farm slaughter accounted for just 93.4 million pounds of red meat—or a paltry 0.2 percent of meat slaughtered commercially.**

Despite this dire conclusion, small farmers do have some choices for operating outside of the USDA system. But these choices come with serious drawbacks. A 2013 [report](#) by the Spokane, Washington, *Spokesman-Review* detailed the problem. Farmers and ranchers are free to use slaughterhouses that are not inspected by the USDA. But meat from animals slaughtered there “must be sold to the consumer before it is butchered.” That means consumers must buy cow, not beef. And they often have to buy hundreds of pounds at a time. “Since a steer yields about 400 pounds of meat, that’s often too much for a single family,” reported the *Spokesman-Review*. “Several families can go together to purchase an animal, but that’s more hassle for the rancher. And it doesn’t address the needs of individuals who just want to purchase a few steaks or some ground chuck.”

This helps explain why on-farm slaughter accounted for just 93.4 million pounds of red meat—or a paltry 0.2 percent of meat slaughtered commercially. This figure includes mobile slaughterhouses, vehicles that travel to farms to slaughter livestock without forcing them to undergo the discomfort and stress required by lengthy travel. All of this helps explain why Rancho was the only independent USDA-inspected slaughterhouse in all of Northern California in 2014. It also explains why most small cattle farmers are forced to use USDA facilities and pass up the local slaughterhouse. Some even literally drive by the latter on their way to the former. “I’m a beef farmer myself,” Rep. Thomas Massie (R-KY) told me in 2015, “and when I take my animals to be processed, I drive past a custom facility three miles from my house and travel three hours to a USDA facility.”

**He’s out almost \$400,000 even though the hundreds of his**

## **cattle that Rancho slaughtered were cancer-free.**

How did we get to this point? As the *Washington Post* [reported](#) in 2010, the “processing, marketing and distribution networks that once made small farming viable . . . disintegrated in the last 30 years as U.S. agriculture went through a dramatic consolidation.” This dramatic decline has occurred even as “demand for pasture-raised niche meats is soaring,” [reported USA Today](#) that same year. In other words, the demand for niche meats is rising fast, but supply is being suppressed artificially by the lack of slaughterhouses.

These problems aren't just evident with cattle and pig slaughter. Consider poultry. Small farmers can slaughter up to 20,000 of their own chickens in a year. And if you're raising and slaughtering that many birds, chances are you can justify the cost of investing in your own processing facility. But very small operations can't afford to do so. And that hurts the smallest poultry farmers, because slaughterhouses are often difficult to find. For example, [Massachusetts](#) lacks a USDA-approved poultry slaughter facility.

## **That program is a bad one for small, sustainable farmers and consumers.**

The impact of limiting where animals can be slaughtered has real world consequences beyond mere inconvenience, including the Rancho recall. The USDA's mandatory recall ensnared not only cancerous cattle processed from (and by) a few bad actors but also that of every other producer who'd had an animal slaughtered in the Rancho plant in the past year—out of what the *San Francisco Chronicle* [termed](#) “an abundance of caution . . . to make sure none of the cancerous meat commingled with healthful beef.” That includes cattle sent to Rancho by celebrated grass-fed farmer Bill Niman, who told the *Chronicle* that he's out almost \$400,000 even though the hundreds of his cattle that Rancho slaughtered were cancer-free and he could prove to the USDA that those cattle were not commingled with the diseased meat. Niman's wife, Nicolette, an environmental law attorney and author of the book *Righteous Porkchop*, penned an excellent [New York Times](#) op-ed lamenting the recall as an overbroad

reaction akin to chopping down hundreds of different orchards thanks to one bad apple. “The Agriculture Department’s tools for safeguarding the nation’s meat supply are blunt and clumsy instruments, especially when dealing with independent farmers,” she wrote. These USDA policies aren’t just stupid—they’re also reckless. And the alleged “abundance of caution” the department claims to be exercising now—after the fact—is entirely the result of its own recklessness.

The Rancho recall is part of a much larger problem that’s existed for decades in the USDA inspection process. That program is a bad one for small, sustainable farmers and consumers. As you’ll learn in chapter 5, the USDA inspection program is now under fire from a bipartisan group of lawmakers in Congress who support small farmers, including some, such as Rep. Massie, who are themselves small farmers. As you’ll learn, Rep. Massie, a Republican, and Democratic colleagues such as Rep. Chellie Pingree (D-ME) and Jared Polis (D-CO), have cosponsored a bill that would permit farmers to expand options for selling meat locally that’s been processed by local slaughterhouses.

Although USDA food-safety rules make selling sustainably raised meat a tough slog, you’re about to learn that state and local food-safety rules are often no less complicated. Food-safety rules that govern the sale of fruits and vegetables, meats and cheeses, and other foods you buy at farmers markets and other local outlets can make doing business difficult— or impossible—for local farmers.

Also tagged [meat](#), [slaughterhouse](#), [usda](#)



**Baylen J. Linnekin** is a food lawyer, scholar, expert witness, adjunct law professor, and Farm-to-Consumer Legal Defense Fund board member. Linnekin’s first book, *Biting the Hands That Feed Us: How Fewer, Smarter Laws Would Make Our Food System More Sustainable* (Island Press, 2016), reveals how regulations often proscribe sustainable food practices. Linnekin’s writings have appeared in the *Boston Globe*, *N.Y. Post*, *Des Moines Register*, *Sacramento Bee*, *Reason*, Huffington Post, VICE, Playboy, *Wisconsin Law Review*, *Hastings Constitutional Law Quarterly*, *Chapman University Law Review*, and elsewhere. He lives in Seattle with his partner of more than 20 years.

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# THE NATIONAL PROVISIONER INDEPENDENT PROCESSOR

## The Least Wanted

February 1, 2007

The Least Wanted

By Sam Gazdziak, Senior Editor

**Things that crawl, fly or go bump in the night can cause severe problems unless they're eliminated.**

With all the safety issues and concerns that come with operating a successful meat-processing plant, the last thing a processor wants to worry about is an infestation of the four-or-more-legged variety. Mice, flies, roaches or any other kind of pest can lower the sanitary conditions of a facility, pose a risk to employee and food safety and generally make for an unpleasant working environment.

When faced with any kind of pest, the recommended route is to hire a professional pest-control expert, says Dr. John Hopkins, assistant professor and extension entomologist at the University of Arkansas' Department of Entomology.

"In a meat-packing or food-processing facility, it's not really a do-it-yourself type of program," he explains. An expert, he explains, will be fully versed in integrated pest management and can use chemical and non-chemical measures, as well as trapping when necessary.

"They will use a full spectrum of control tactics," Hopkins notes.

Integrated pest management involves gathering the most information to make the best decisions in regards to pest control. Ideally, it would be implemented before there is an emergency need for pest control or when there is a risk of violating government regulations. But it takes into account such things as the long-term effects of using pesticides, not only to employee health but also to

profitability and the possibility of pesticide resistance. Solutions that might be taken into account include introduction of natural enemies, cultural management, temperature and other physical controls, sanitation and pesticides.

To keep a plant's critter count down, Hopkins advises to keep the plant in a proper state of repair, both inside and outside. That includes eliminating ways for vermin to get into the facility as well as removing places that would be harborage areas on the outside. Pallets or boxes stacked up on the outside of the building would make a nice home for rodents, as would large bushes next to the building.

"You want to keep the outside of the building clean, and keep shrubs trimmed back from the edges of the buildings," he says.

What follows are a few of the pests that might terrorize meat- and poultry-processing plants, and how to deal with them.

### Cockroaches

Cockroaches of various species can contaminate food with their droppings, their bodies or the bacteria they carry. Several types of *Salmonella* and *Staphylococcus* can be traced to their presence, along with dysentery and cholera. They hide during the day and only come out to feed at night. They eat almost anything man eats, as well as glue, paste and fecal material, among other human inedibles.

The presence of cockroaches can usually be seen by cast skins, egg sacs and droppings. If there's a high infestation, there may also be a noticeable musty smell. The use of insecticides and the destruction of their feeding and breeding grounds are needed to get rid of them. Professionals are often needed in the application of the pesticides because of government regulations that determine where and how the chemicals can be used in food-processing plants.

### Flies

Outside of a home or office, flies help in the decomposition of animal carcasses and are a food source for many animals. Inside a building, they are annoying at best and a health and food hazard at worst. There are several different types of flies that might take up residence in a food-processing plant, including the house fly, the fruit fly and the green bottle and blue bottle fly. If they are to be found anywhere inside a building, it would most likely be near decaying organic matter, whether it's in garbage bins or animal carcasses. They can carry diseases, making it critical that they be kept out of processing plants.

Keeping outdoor trash bins far from the facility is one way of keeping flies on the outside of a plant. Inside or outside, refuse bins and the areas around them should be cleaned and sanitized regularly. Windows should be screened, and wind curtains can be used to prevent them from flying indoors.

### Rodents

If a processing facility has readily available food, water and shelter, rats and mice may soon consider the building home. Without proper plant sanitation, there will be plenty of things in that plant on which rodents can feed. Dripping water pipes will provide a water source for rats, and piles of boxes and tall weeds can supply the shelter. Rodents can contaminate food products with

both their own fecal material and with anything on their feet that they track into a plant — rats and mice are not known for traveling through clean places.

In the event of a rodent infestation, droppings will be visible and loose food items will indicate where they have been feeding. Rats tend to use the same pathways while moving between food, drink and shelter, and as they rub their bodies against a wall or other vertical surface as they travel, they will form a greasy mark against the surface.

Taking away the sources of food, drink and shelter will discourage the rats from entering a building. Plants can be designed to be rodent-proof, drainage ditches and other standing water sources should be eliminated, and food items should be kept in rodent-proof containers.

Warehouses should be kept orderly, and a strip of light-colored paint should be painted on the floor around the walls of a warehouse to easily identify any signs of rats. NP

For more information: A training manual, Food Manufacturing, Processing and Storage Pest Control, is available from the Department of Entomology at the University of Arkansas at [www.uaex.edu/Other\\_Areas/publications/HTML/MP-443.asp](http://www.uaex.edu/Other_Areas/publications/HTML/MP-443.asp)

### **Pest control around live animals**

If a processing plant also has a slaughter area, measures have to be taken to control pests that might gather there. Removing manure and other organic matter on a regular basis is critical to prevent swarms of flies from surrounding the area. Standing water can attract mosquitoes, whose bites can irritate the animals as well as spread disease. There are some insecticides that are safe for use around livestock, but an expert should be consulted before any such measures are introduced. Another concern with live animals is lice and other vermin that can cause discomfort to the animals and lead to a less-than-optimal carcass. Hogs, for example, are susceptible to hog lice and mites that cause mange. There are sprays, powders and feed additives that can treat these problems, but they need to be used on a regular schedule, both at the farm where the animals are raised and at the slaughter facility.

*For more information about live animal pest control, visit Purdue University's Department of Entomology home page at [www.entm.purdue.edu/Entomology/ext/index.htm](http://www.entm.purdue.edu/Entomology/ext/index.htm)*

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# The Water Footprint of Beef: Industrial vs. Pasture-Raised

In footprints, water in your food 11/30/2018



Beef has a large water footprint and the system in which cattle are produced can make a substantial difference in the size of the footprint. While pasture-raised beef can be more sustainable, many assume that its water footprint is always smaller than that of industrially produced beef. This is not necessarily the case, although it can be more water friendly.

## Beef's Big Water Footprint

People often ask, “What’s the best way to reduce my water footprint?” and the conversation always drifts to meat eating. That’s because meat, especially beef, has a large water footprint — **1,800 gallons** of water per pound of beef produced.